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AIR & SPACE

Smithsonian

Helicops at Work: Fighting Crime by Air

How the P-51 Mustang Was Born (and why it had more than one father)

"We'll Trade You One Jet Fighter for a Boatload of Pizza"

Page 60

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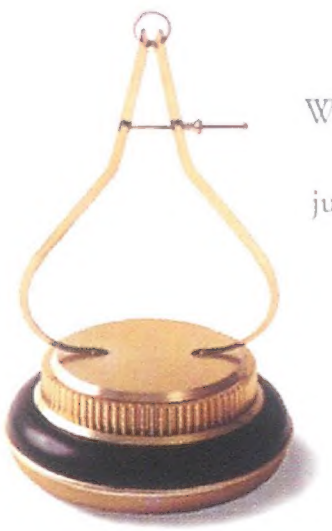
CHEVY TAHOE. MOTOR TREND *1996* TRUCK OF THE YEAR.



The best was all it took to satisfy Winston Churchill. And the best is what the judges at Motor Trend search for each year. They found it in the 1996 Chevy Tahoe.

They call Tahoe "A class act."

"A virtue-packed machine that delivers a unique bundle of attributes."

They took Tahoe out on the road and discovered its Vortec 5700 V8 has "Power to spare." "Although... it's a big vehicle, it's easy to drive on twisty roads." And "It will handle all you can dish out and then ask for more."

Then they looked further into Tahoe and found "Thoughtful touches abound throughout" its brand-new interior.

In fact, no matter where they looked, they couldn't find a vehicle quite like Tahoe. Nothing else had its unique combination of room, features and power.

So they stated that Tahoe "Forges out a new niche."

Obviously, the judges were satisfied.

LY SATISFIED WITH THE VERY BEST."

-WINSTON CHURCHILL

CHEVY TAHOE
LIKE A ROCK

August/September 1996
Volume 11, Number 3

AIR&SPACE

Smithsonian

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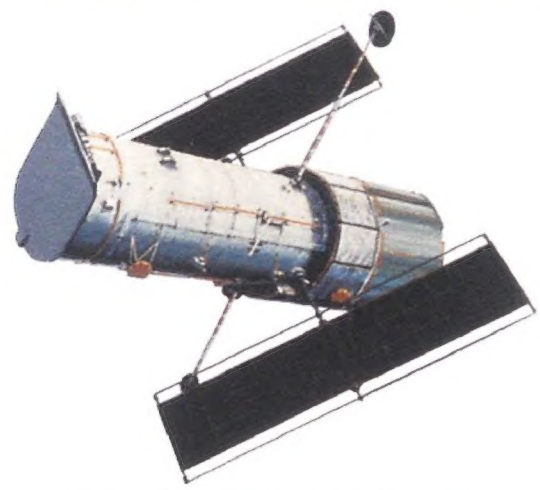
THE VIEW FROM THE HUBBLE: PART II



34 Splendor in Space
by Tony Reichhardt
Captions by Gerrit L. Verschuur

As this collection of images demonstrates, the Hubble has returned some spectacular visions of our universe. Want to take some? Get in line.

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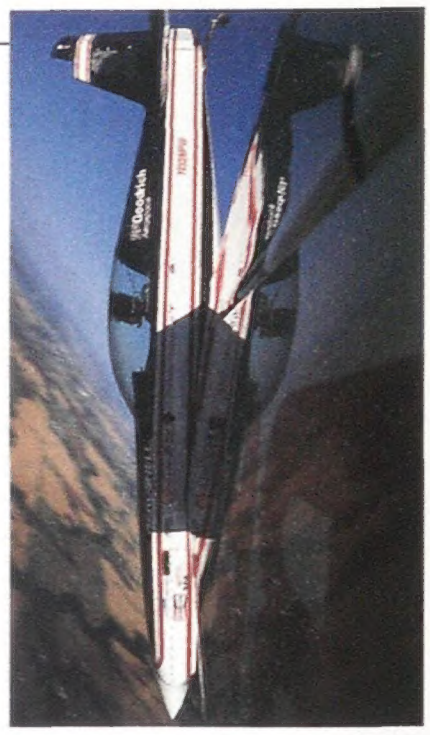

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Cover:
Chad Slattery photographed MD 500 pilot Larry Kroesche and observer Mario Medina on patrol over Houston.

Departments

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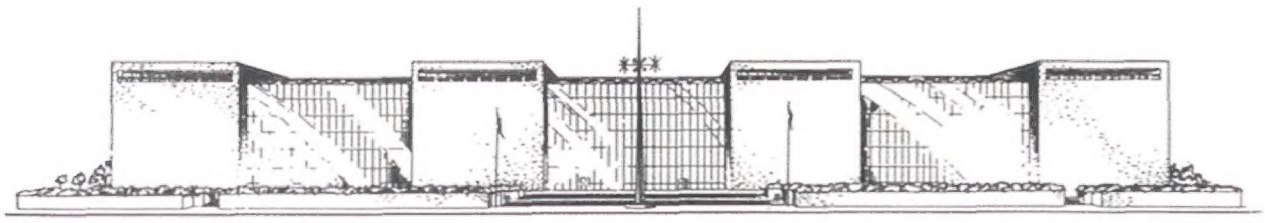

Double Whammy

The political machinery of Washington has decided that the Federal Aviation Administration needs to be fixed in two important ways. One has made the news and one hasn't. The one that got coverage was Secretary of Transportation Federico Peña's exhortation to Congress to alter the FAA's basic charter. The other, familiar mainly to aircraft operators and pilots, would change the way the aviation infrastructure is paid for.

When created in 1958, the FAA was charged with both "the regulation of air commerce in such a manner as to best promote its development and safety" and "the promotion, encouragement, and development of civil aeronautics." After the FAA decided to shut down Valujet, a discount-fare airline with a history of non-fatal mishaps and one fatal crash in the Florida Everglades, Peña urged Congress to delete the FAA's responsibility to "promote" aviation and order the agency to focus on safety. In 1958 both President Eisenhower and the Congress seemed comfortable with the agency's mandate, and only in the last 20 years has a perception spread that "safety" and "encouragement" are somehow mutually exclusive.

That perception can be attributed to the consumer movement, which sees the world through a filter that colors business in tones of malevolence. But aviation is different from most business. If you manufacture airplanes or operate an airline in such a way that you crash a lot, you will soon be out of business. (It is appropriate to point out here that U.S. airliners do not crash a lot.) This makes it hard to conceive of airline executives and FAA inspectors huddling in darkened rooms plotting ways to undermine safety, yet that's what many critics seem to suggest. By contracting out most of its needed services to vendors, Valujet operated differently from most airlines, and the FAA did seem slow in responding to this new approach. Those observations notwithstanding, the proximate cause of the Valujet crash should be determined and stringent preventive measures taken (i.e., no more oxygen generators in cargo holds); blaming the airline's performance on the FAA charter requires a feat of mental gymnastics.

But there's more. Part two involves the expiration last December of a tax on aviation fuel and airline passenger tickets, and as we go to press, the surplus of the previously collected taxes that had accumulated in a special trust fund was being drawn down as fast as a gambler's line of credit. Some blame election year politics for the failure to renew the tax, but part of the hold-up is the re-introduction of an old idea: user fees, in which a pilot who wishes to use the air traffic control system to enhance the safety of a given flight would pay by the mile. On the surface this is an attractive idea. Those who use a service should pay for it. But user fees are just another name for a tax imposed on a smaller group of people. The trouble is that taxes affect not just people's wallets but their behavior.

For years the FAA has tried to improve the safety of air transportation by encouraging all pilots to obtain instrument ratings and fly within "the system." Under the proposed user fees, general aviation pilots would have an economic incentive to avoid using the system. In the relatively empty skies of the Midwest, say, that isn't much of a problem. In the often crowded and sometimes chaotic skies on the coasts, however, all pilots should be encouraged to use—not discouraged from using—air traffic control. There is a public benefit in safety that should not be ignored as part of a larger agenda whose purpose is to balance the budget.

It's this simple, or it should be: All "users" who fly pay for the system under a fuel or ticket tax, whether they use the services of an air traffic controller or not. Force these same people to buy services à la carte and they will try to save money.

If this second big change didn't make it into your local paper, we're not surprised. But we thought you should know; it is, after all, your sky.

—George C. Larson

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TECHNOLOGY UPDATE

500 miles from nowhere, it'll give you a cold drink or a warm burger...

This NASA-inspired portable fridge outperforms conventional fridges, replaces the ice chest, and alternates as a food warmer!

by Brad P. Richardson

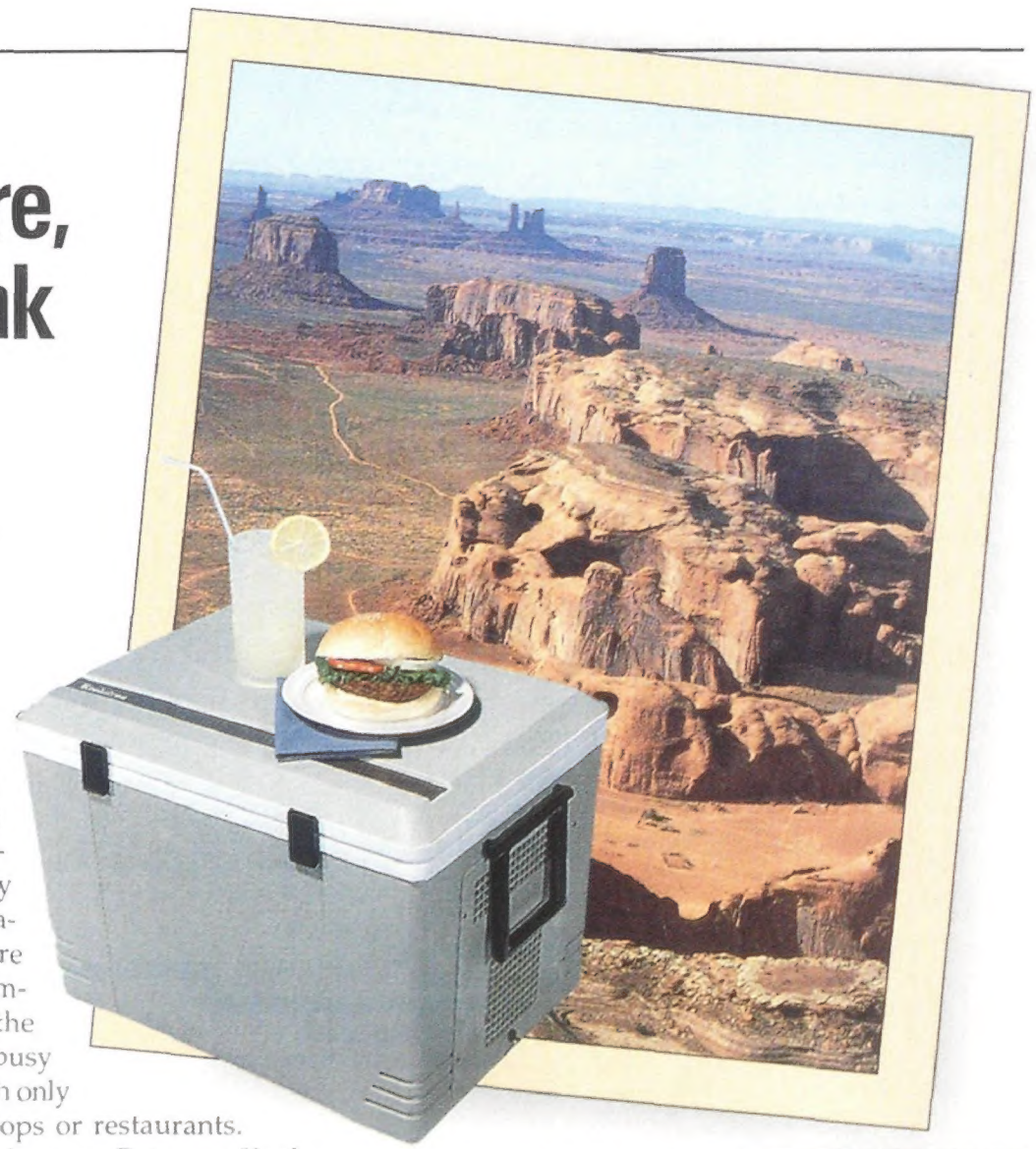
Recognize the ice cooler in this picture? Surprisingly enough, there isn't one. What you see is a Koolatron, an invention that replaces the traditional ice cooler, and its many limitations, with a technology even more sophisticated than your home fridge and far better suited to travel. What's more, Koolatron is not just a refrigerator—it's also a food warmer!

NASA-inspired portable refrigerator. Because of the tough demands of space travel, scientists had to find something more dependable and less bulky than traditional refrigeration coils and compressors. Finally, research led them to discover a miraculous solid-state component—the thermoelectric module.

Besides a small fan, Koolatron has no moving parts to wear out or break down. And it's not affected by tilting, jarring or vibration, which often cause home fridges to fail. The governing module, no bigger than a matchbook, delivers the cooling power of a full 10-pound block of ice.

From satellites to station wagons. Thermoelectric temperature control has been proven with over 25 years of use in the most rigorous space and laboratory applications. Koolatron is the first manufacturer to make this technology available to families, fishermen, boaters, campers and hunters—to anyone on the move.

Home refrigeration has come a long way since the ice box and blocks of ice. But when we travel, we go back to messy ice coolers and soggy, even spoiled food. Now for the price of a good cooler and one or two seasons of buying ice, (about five family restaurant meals) all the advantages of home cooling are available for travel—electronically!



Consider your last trip. You finally got away on your vacation, and are cruising comfortably in the car along a busy interstate with only a few rest stops or restaurants. The kids are hungry. But your Koolatron is stocked with fruit, sandwiches, drinks and fried chicken—all fresh and cold. Everybody helps themselves. You have saved valuable vacation time and avoided another expensive restaurant bill.

Hot or cold. With the switch of a plug, Koolatron becomes a food warmer for casseroles, burgers—even a baby's bottle. It heats up to 125 degrees. And because there are no temperamental compressors or gases, it works perfectly under all circumstances—even when upside down. Empty, the large model weighs only 12 pounds. And the smaller one weighs just seven. Full, the large model holds up to 40 12-ounce cans, and the smaller one holds six.

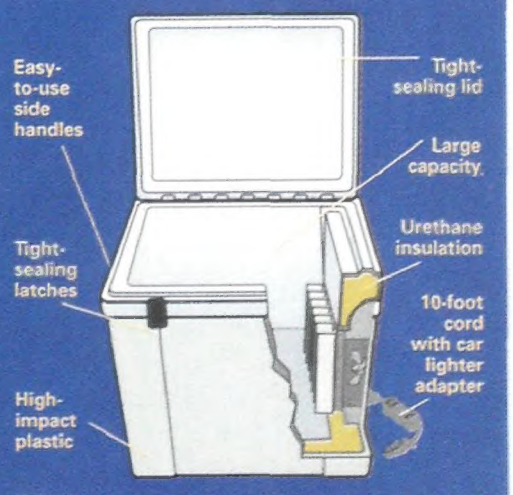
Just load it up and plug it in. On motor trips, plug Koolatron into your car's cigarette lighter. It uses less power than a tail-light. If you decide to carry it to a picnic spot or a fishing hole, the Koolatron will hold its cooling capacity for up to 24 hours. If you leave it plugged into your battery with the engine off, it will consume only three amps of power.

Factory-direct offer. Because Comtrad is bringing this offer to you directly, you can save the cost of middlemen and retail markups. For a limited time only, you can get Koolatron's advanced technology at the special introdutory price of just $99. Call today and take advantage of this promotional pricing!

Try it risk free. As with all of our products, Koolatron is backed by Comtrad's exclusive 90-day risk-free home trial. Try it! And if you're not completely satisfied, return Koolatron within 90 days for a full refund—"No Questions Asked." It is also backed by a full one-year manufacturer's limited warranty.

Koolatron is compact enough to take to your campsite, on a picnic or on the road in your car.

The refrigerator from outer space



The secret of the Koolatron cooler/warmer is a mini thermoelectric module that effectively replaces the bulky piping coils, loud motors and temperamental compressors used in conventional refrigeration. In the cool mode, the Koolatron reduces the outside temperature by 40° F. With the switch of a plug, it becomes a food warmer, going up to 125°.

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LETTERS

Aerial Animals

"Dog Is My Copilot" (June/July 1996) brought back memories of a unique copilot who flew with my husband during World War II.

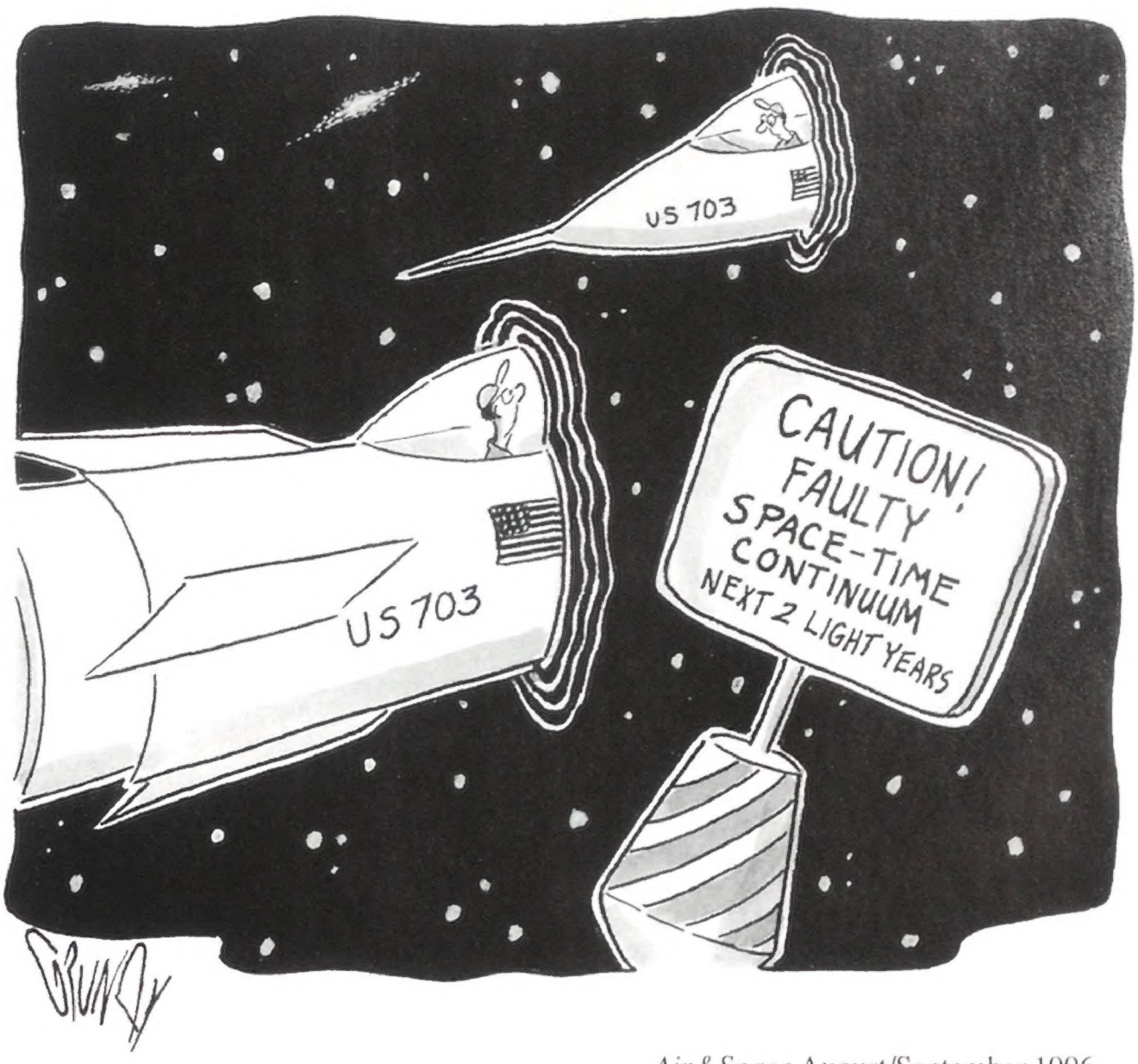
Rick flew out of Miami on the Fireball Express, a high-priority freight and passenger service that was part of the Air Transport Command. His route passed through Brazil and over the South Atlantic to Africa and India. One day a friend gave Rick a baby female marmoset from the jungles of Brazil.

Rick taught Baby Butch to ride on his shoulder and not bite him. In calm weather she would sleep on the radio, and during turbulence she would cling to the bungee cords that supported the compass in the "V" of the windshield. She also made short work of any insects in the cockpit. She would hold the wings of a moth, munch on the body, and then stuff the wings in her mouth.

She also came up with the idea of startling bar patrons by boldly approaching their drink glasses and sitting up on her hind legs. She was no bigger than a highball glass, and the sight of her probably reformed a number of topers.

—Gail S. Ravitts
Rockford, Illinois

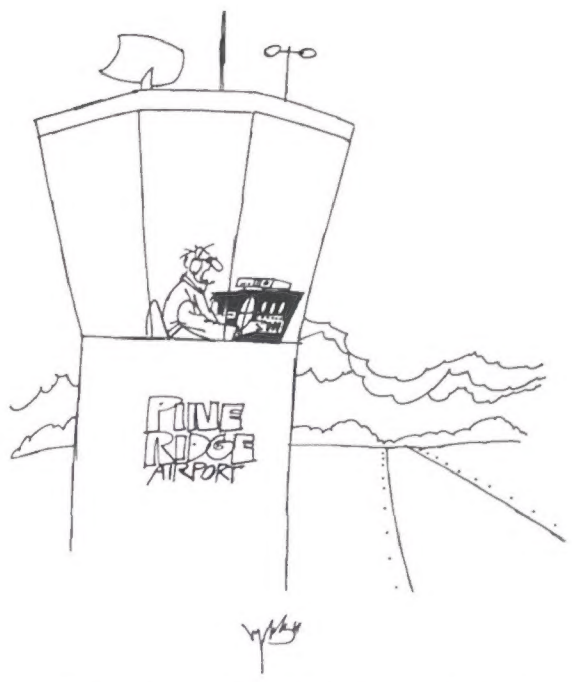
The photograph of Melvin Vaniman and the cat Kiddo in "Dog Is My Copilot" set me scrambling through my microfilm news accounts of this attempt by *Chicago Record-Herald* journalist Walter Wellman to cross the Atlantic in an airship. As I



remembered, Kiddo had even merited an editorial in the *New York Times*, in which the writer wondered why everyone was showing so much concern over a cat, a "creature so self centered, so imperfectly domesticated, so unmindful of past favors, so ready with sharp claws to punish an unintended affront or injury which the infinitely nobler dog would either ignore altogether or instantly forgive." The *Times* also hinted darkly that as the airship was going down and Wellman and his crew were risking their lives to save the cat, Kiddo no doubt dug in his claws and resisted rescue to the last.

On the other side of the question came this jibe from Wellman's crosstown rival, the *Chicago Tribune*: "We can fully understand why Wellman and his companions embarked on a voyage which for foolhardiness exceeds anything in the history of human recklessness, but what gets us is how a perfectly sane cat ever consented to go."

—P.J. Capelotti
via e-mail



"I need your heading, airspeed, and altitude. I don't need your e-mail address."

Big Dreams

In 1965, Joseph Foa of Rensselaer Polytechnic Institute in New York was granted a patent for a transportation system involving a vehicle propelling itself at high speed through a tube, similar to the one described in "An Express of the (Near) Future" (From the Field, Dec. 1995/Jan. 1996). The vehicle he proposed would initially be accelerated by a rocket or similar motor in the tail. Once it was traveling fast enough, a ramjet-like engine in the vehicle's nose would take over. The ramjet would have a spike intake diffuser, and nozzles downstream from the intake would supply fuel for mixing with diffused air. (The passenger or crew compartment would be ahead of the hot combustion region.) Propulsion would take place by the fore-to-aft transfer of air in the small space between the vehicle and the surrounding tube. Foa envisaged that the transfer of air could take place either as the effect of the ramjet or by means of magnetohydraulic body force (which I take to be the same as MAGLEV).

Most tube-enclosed vehicle concepts would cause large displacements of air within the tube. With Foa's design, if one or both ends of the tube are closed, the air in the tube remains substantially at rest everywhere except around the vehicle. Therefore, once the vehicle reached a steady speed, which would certainly be supersonic, the amount of energy required to propel it would be very small.

—John Kay
Chevy Chase, Maryland

A Disastrous Miscalculation?

People who put too much faith in mathematics tend to lose touch with

reality. In his review of *The* Challenger *Launch Decision* (June/July 1996), Bruce Berkowitz seems to propose that what killed the crew of the *Challenger* wasn't flawed engineering but rather probability.

—Paul N. Nash
Oakton, Virginia

Breaking the Laws of Man and Nature

Now that you have published an article glorifying a bunch of flying criminals ("The Contrabandistas," June/July 1996), I can hardly wait for one praising arsonists, bank robbers, murderers, and all the other scum of the earth. Shame on you!

—Glenn R. Jordan
Pisgah Forest, North Carolina

"The Contrabandistas" was most interesting and informative. It explains what a lot of my crazier friends were doing in those days.

The article refers to the DC-3's cargo capacity as 26,900 pounds. Actually, that is its designed maximum gross weight.

—Jim McLaughlin
East Tawas, Michigan

The DC-2.5

In his letter in the last issue, John Lenci wondered why a picture of the East German Model 152 appeared to show the craft sporting two different wings. There is an earlier example of such a hybrid. Stan Cohen's book *Wings to the Orient*

tells of a DC-3 that lost a wing to Japanese air attack in the late 1930s and was forced to land. "There were no spare DC-3 wings to fix the plane," writes Cohen, "only a DC-2 wing stored 800 miles away. William Langhorne Bond, who ran CNAC [Chinese National Aviation Corporation] for Pan Am and the Chinese government, ordered the DC-2 wing flown to the downed aircraft and attached...in the hopes it would get the plane off the ground. It miraculously worked and the DC-3 took off and flew to its destination."

—Earl Hinz
Honolulu, Hawaii

More Sorry and Not-So-Sorry Stories

In "The Sorry Saga of the Brewster Buffalo" (June/July 1996), Daniel Ford omitted mention of the American Volunteer Group's experience with the aircraft. In 1941 the AVG was forming up at Toungoo, Burma. The Royal Air Force, still at peace in the East, was flying Buffaloes. Claire Chennault was tempted by the advantages of air-cooled engines, and he was pressured to make a swap: P-40s for Buffaloes. But cannily, and most fortuitously, he staged a trial before deciding. AVG pilot Eric Shilling, famed for creating the shark faces that became the Flying Tigers' trademark, went up in a P-40 against an RAF combat veteran in a Buffalo. And Shilling turned him every which way but loose.

It was for the best. Buffalo horns on the flying beer barrels just wouldn't have had the panache of Flying Tiger sharks.

—David H. Rust
Woodville, Texas

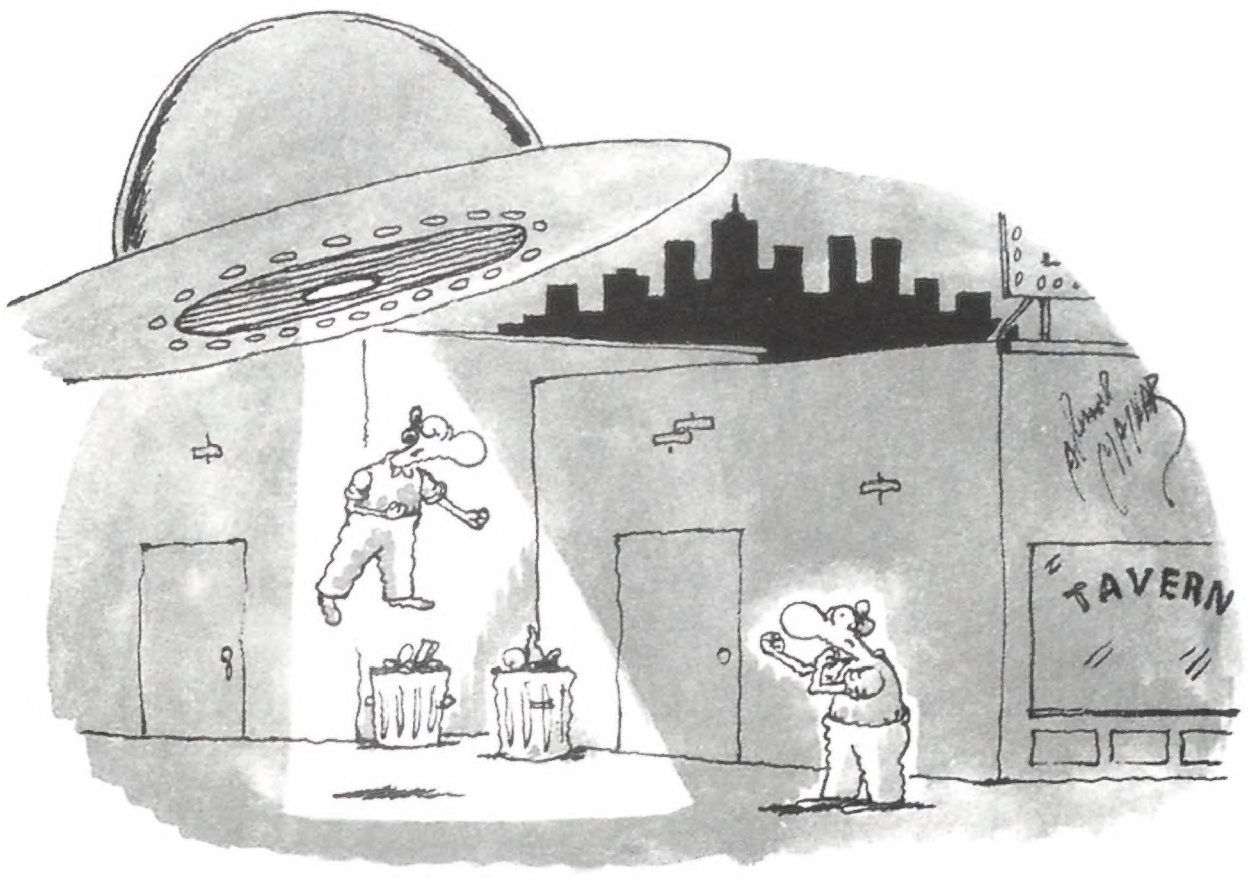
Daniel Ford stated that the Finnish air force significantly "overclaimed" the victories its pilots scored flying Brewster Buffalo B-239s against enemy aircraft. I disagree. In 1990 I did a bit of research on the record for *Aviation History*, using a history that presents details about each Finnish air force aircraft and ace. (The Germans and Finns have been exceptionally accurate in crediting their claims, according to Christopher Shores in *Air Aces*.) My research showed that the Finnish Brewsters defeated 447 enemy aircraft in aerial combat, including everything from the I-15bis, the MiG-3, and the Yak-7 to Soviet-flown Hurricanes and Spitfires.

Of 44 Buffaloes, the Finns lost 16 in enemy action and 20 in other circumstances. If you define the kill-to-loss ratio as the number of kills in combat divided by the number of losses in combat, the benighted Buffalo has a ratio of 27.94. As far as I can tell, that is higher than any other fighter of World War II.

Incidentally, almost all of the Buffalo's kills were made by Finnish aces. The best was Ilmari "Illu" Juutilainen, who scored 94 1/6 victories—more than any other non-German in World War II and 14 kills more than the first world war's Red Baron.

—Edward Morrison
Houston, Texas

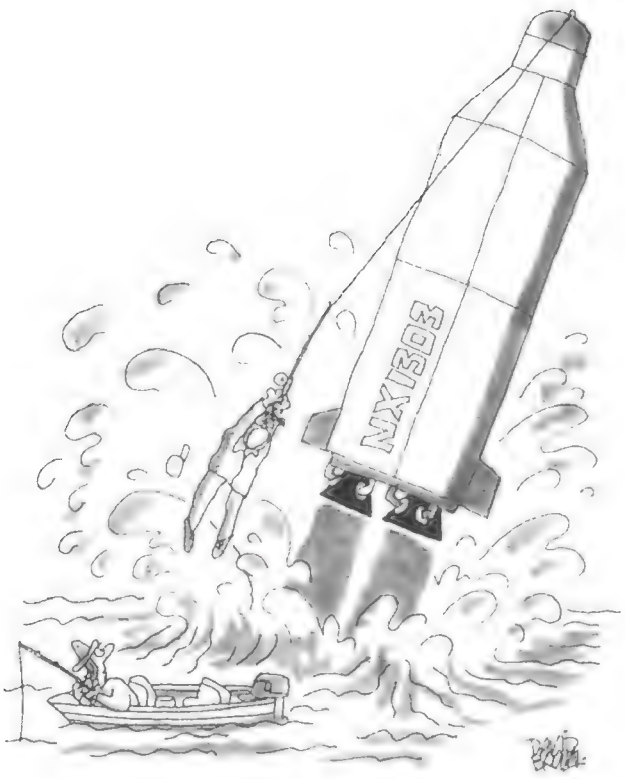
Daniel Ford replies: Happily, Juutilainen's autobiography, Double Fighter Knight, *should be out in September (published by Apali Oy, distributed by Motorbooks).*



"You're just lucky I'm being abducted by aliens, pal!"

Wanted: USAF Mementos

The Discovery Channel, the Air Force Association, and CreatiVentures, Inc., are developing a two-hour TV special and coffee table book to commemorate next year's 50th anniversary of the U.S. Air Force. The producers seek stories, letters, photos, film footage, and other material on the Air Force's history. Send material, along with a note indicating whether you want it returned, to: CreatiVentures, Inc., Attn.: AF 50th, 3823 Plaza Drive, Fairfax, VA 22030.



Sex and Aviation: Uneasy Bedfellows?

I was shocked to read "Gossamer Wings" (Flights & Fancy, June/July 1996). This type of writing is usually associated with low-class, trashy publications.

When I subscribe to an aviation magazine, I want to read about aviation, not sex. Recently, I have had to cancel subscriptions to *Flying* and *Private Pilot* because of articles and a drawing that featured sex.

There are many very sick people in the media today who are helping to lower moral and ethical standards in the United States. I hope and pray that your writer will not contribute to this trend and ruin *Air & Space*.

—Mary Proko
Elmira, New York

Moving on to Lighter Matters

Whatever happened to Brunolf Baade, one of the main characters in "The Rise and Fall of the East German Aircraft Industry" (Feb./Mar. 1996)? We lose track of him about a year after the crash of the Model 152, when he announced that deliveries would be postponed.

—J.W. Freeman Jr.
Kansas City, Missouri

Editors' reply: Baade was reassigned. He established the Institute for Lightweight Construction, a small agency that promoted technologies to reduce aircraft weight, and he died seven years later, at the age of 65.

An Old Family Friend

On page 71 of your excellent article "A Pacific War Album" (Aug./Sept. 1995), you show a picture of the theater Air Force commanders preparing for the final assault against Japan. One of the officers was listed as "unidentified." My father, Brigadier General Walter Reed, considered this man one of his dearest friends, and commanded the Seventh Air Force Service Command under him. He is Major General Willis Hale.

General Hale faced enormous difficulties in his efforts to implement Army Air Force strategic air operational concepts within a predominantly naval theater of operations. His success was recognized in May 1944, when he was selected to serve as commander of all shore-based aircraft in the forward area.

—Lt. Col. Walter J. Reed Jr.
U.S. Air Force (ret.)
(no address provided)

The Idleness of the Long-Duration Astronaut

It amazed me that "The Loneliness of the Long-Duration Astronaut" (June/July 1996) makes no mention of astronaut art. For us lonely retirees, art is a great way to be creative. But the crew psychologists seem to have forgotten what good therapy art is. Also, there was no mention of crossword puzzles or word games.

The question that should be answered is: What do these people do in outer space that makes them so lonely? Maybe it would be cheaper for us taxpayers if they stayed home, where they can keep busy.

—Phil Quedens
Berlin, Connecticut

Corrections

Apr./May 1996 "Aviation's Belle Epoque": The aircraft shown on p. 25 was produced by Henri Farman, not Gabriel Voisin, and the Blériot on p. 27, though a Model XI, is not the one that crossed the English Channel.

Feb./Mar. 1996 Update (Soundings): Admiral Isoroku Yamamoto was shot down over Bougainville, not Papua New Guinea.

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Out of the Blue

Give the Air Force credit for the dramatic touch. When it unveils a new addition to its museum in Dayton, Ohio, the pomp and ceremony are straight out of Las Vegas—particularly in the case of Tacit Blue, the recently declassified surveillance aircraft put on display last May.

"Ladies and gentlemen: Tacit Blue," announced General Robert Bongiovi to the applause of an outdoor audience of about 400, mostly industry and military personnel who had worked on the airplane. As a six-piece Air Force band in dress blues struck up Wagner's solemn "Elsa's March to the Cathedral," the huge hangar doors slowly parted to reveal the ungainly aircraft bathed in spotlights. It was framed by a B-17 and *Bockscar*, the B-29 that dropped an atomic bomb on Nagasaki in 1945.

Tacit Blue is a minor star in comparison, an experimental stealth technology demonstrator that flew less than 250 hours before being mothballed in 1985. The Air Force wanted an aircraft that could operate undetected above battle lines, sending back real-time information, a function undercut by Tacit Blue's high visibility in daylight. Nonetheless, the Northrop effort was touted at the ceremony as "one of the most successful technology demonstration programs in Air Force history," though its specific accomplishments remain vague. Even a simple query regarding flight test locations drew a coy response of "Oh, about 30,000 feet" from a project engineer, who shrugged and added, "That's what they tell us to say."

The most striking thing about Tacit Blue is its odd, bloated appearance, which led to its being nicknamed "the whale." The aquatic analogy is reinforced by an upcurved tail, and the smooth, unriveted fuselage curves into a chine ringing the entire craft. All this contributes to a low radar cross-section, but it also made Tacit Blue a beast to fly, unstable in pitch and yaw, controllable only with a quadruple-redundant digital fly-by-wire flight control system. "You look at the plane and say,

USAF

'Wow, that doesn't look very aerodynamic,' " admitted Air Force test pilot Ken Dyson. "Then you look at the aerodynamics of it and you say, 'Wow, that doesn't look very aerodynamic.' "

Dyson wasn't giving away any secrets either. "There are stories to tell," he teased, "but it was a long time ago and I'm not sure I remember them." Still, he allowed that Tacit Blue did live up to one of its other nicknames—HUM, for Highly Unstable Mother. "I can't believe how many times I crashed it in the simulator," he said.

The airplane made 135 flights without incident, though to judge from the speeches at the unveiling, the hardships imposed by Tacit Blue security requirements made working on the Manhattan Project a breeze. "It is the lot of some men to be assigned duties of which they may not speak," intoned retired Northrop Grumman project manager Stephen Smith, recounting five years of stoic silence at the family dinner table. And there was Mary Lou Twigg, the wife of the Air Force program manager, who took it on the chin one day for innocently buying a whale pendant. "I totally alarmed her, with no explanation, when I suggested that she not *ever* wear it," said Colonel John Twigg.

Before the ceremony was over, everyone, including family members, was asked to stand and take a bow. Afterward, pilots and engineers posed for pictures in front of the airplane, trading handshakes and backslaps. Tacit Blue was rolled out for some final glamour shots in the sun before being put on permanent display in the Modern Flight gallery with various X-planes—just as soon as the cafeteria renovation is done.

—Frank Kuznik

PAUL D. MALEY

Making the rounds at Johnson Space Center after the failure of the tethered-satellite experiment last February (see "Heart Breaker," From the Field, June/July 1996):

Top NASA Excuses for Tether Break

- Overwhelming desire to say "Houston, we have a problem."
- Forgot to tie a knot on the end of it.
- The string broke when they tried "around the world."
- Dan Quayle is no longer there to look after things.
- "Mikey did it."
- "Hey guys, check this out! It keeps going and going..."

NASA says the actual reason was a puncture in the tether's insulation that allowed an electrical current to jump from the 12-mile copper cord to a nearby electrical ground, burning through the tether.

Occupational Hazard

During a day-long symposium on the risk posed to astronauts from the radiation they're exposed to in space, one presenter after another raised a theme popularized in the 1969 film *Butch Cassidy and the Sundance Kid.* In a famous scene, the Kid, who has by this time braved death at the hands of various gunslingers, balks at leaping from a cliff into the river below. When he confesses he can't swim, his partner in crime points out that he shouldn't worry because "the fall will probably kill ya."

For astronauts, the increased risk of death from cancer caused by exposure to solar and cosmic radiation is pretty low when compared with the other dangers of spaceflight. In the ugly mathematics of probability and statistics on which risk assessments are based, a vehicle failure is more likely to kill them. So the risk analysts and theoreticians convened by the National Council on Radiation Protection and Measurement in Washington last May confessed to having trouble with the symposium's topic: the "acceptability" of an astronaut's occupational hazard from radiation effects.

In 1989, the NCRP, an advisory body chartered by Congress in 1964 to analyze information about radiation and make recommendations to the public, established career limits of 150 rem for male astronauts and 100 rem for females. (A rem is a measure of the biological effect of a given quantity of X-rays.) In arriving at this number, the council faced a difficult question: Should it, for health reasons, limit the number of missions astronauts could fly? The council calculated that exposure at the upper limit would increase an astronaut's risk of fatal cancer by three percent over that faced by the general population. The purpose of the symposium was to re-examine this limit and the ethics involved in considering the risks. One of the afternoon speakers gave the council plenty to think about.

Astronaut Ellen S. Baker, who received her M.D. from Cornell University in New York, began her remarks with the disclaimer that she was one of those "paranoid and hypochondriacal medical personnel who tend to get more hysterical about medical issues than the average pilot would." What she presented, however, was a thoughtful, somber appraisal of the risks astronauts are asked to accept, and she offered the scientists at the symposium the rare chance to hear from a real, live experimental subject.

"A three percent excess risk doesn't sound like much unless you're the one who gets the cancer," Baker said. She went on to tell a few stories that made radiation a more tangible threat than the morning's presentations had—like one about the mission to launch the Hubble Space Telescope in 1990, when the space shuttle flew higher than it ever had before. When the shuttle returned to Earth, technicians found that all the film aboard the orbiter had been fogged from radiation exposure.

Baker was followed by former astronaut William Thornton. Although he is a medical doctor, now on the faculty of the University of Texas, he is also a former jet pilot, and he supplied what might be called the pilot's point of view. "I am confident that radiation problems will be dealt with competently," he said. Thornton did express concern that the emotional response to the radiation risk might diminish public support of the space program. "The public tolerates largely preventable loss of life from automobiles and handguns," he said, but objects to risks from radiation because of the "emotional load" radiation carries.

Thornton and Baker agreed that "tracer studies," medical experiments using radioisotopes, should be limited. They also supported the application of the NCRP's ALARA principle—that radiation exposure should be As Low As Reasonably Achievable. During a panel discussion in which both astronauts participated, a panel member pointed out that NCRP should include astronauts in the risk management process. "They are technically trained and, many of them, medically trained. And they are the experts on the ethical problems," he said.

In response to questions about the other risks that space travelers accept, Baker replied, "Astronauts clearly accept more risk than many do, but that doesn't mean we should accept any risk." She advocated that NASA study other options for limiting dosages besides restricting careers, including pharmacological techniques and shielding. With 90-day missions aboard the international space station about to become routine, NASA, which supported the NCRP symposium, is studying all of the issues involved in subjecting human explorers to radiation in space.

—Linda Shiner

UPDATE

DarkStar Crashes

The DarkStar unmanned reconnaissance craft crashed and burned on its second flight last April at California's Edwards Air Force Base (Soundings, Aug./Sept. 1995). Immediately after takeoff, the craft began a series of pitch oscillations, nosed up 90 degrees, then rolled to the left and hit the ground. The first flight of the Lockheed Martin-Boeing craft, made late last March, had met all objectives. A second DarkStar airframe is being rushed into flight readiness to take the place of the first test aircraft.

NASA Goes Prime Time

First it was "NYPD Blue." Then "ER." Now space shuttle astronauts are about to be serialized, like the police officers and emergency room teams before them, in a weekly TV drama. "The Cape," shot in and around the Kennedy Space Center in Florida, is set to air in syndication across 90 percent of the country in September.

Inspired by the popularity of last summer's movie *Apollo 13*, executive producer Kary Antholis decided it was high time for a series that portrays the

professional and personal lives of contemporary astronauts. MTM Television bought a two-hour pilot and 20 episodes sight unseen.

The show aims to present the lives of contemporary astronauts—to expose human foibles and failings, albeit with the dramatic license of "heightened reality" and a decidedly pro-NASA slant. "We're not here to whitewash anything," says Antholis, but the producers believe there's a "dignity" in being an astronaut that must be preserved. "We're going to have to get into conflict and issues and everyday drama," he says, "but what we hope to do is maintain a level of reality and professionalism in these people that adheres fairly closely to reality."

Corbin Bernsen of *L.A. Law* fame stars as Barry "Bull" Eckert. In the pilot, Bernsen's character commands a shuttle mission to rescue a nuclear-powered Russian spy satellite from its decaying orbit, thereby saving a metropolitan area from the threat of mass radiation poisoning. The two-hour movie uses video footage of the May 1992 spacewalk by three *Endeavour* astronauts who wrestled a stranded Intelsat satellite into the shuttle.

Shooting began last May and will continue through November along Florida's "Space Coast." The sets include an astronaut office, a crew dormitory, a watering hole called the Moonshot Bar, and a detailed mockup of the orbiter's crew cabin built by the Kansas Cosmosphere Spaceworks. Kennedy venues to be glimpsed in the show include the launch control center, the shuttle landing facility, and the Launch Complex 39 press site. Many of the extras are NASA employees or contractors.

Art does not always imitate life in "The Cape." "Our astronauts are a little bit younger, and a few more of them are single," compared with real ones, says Antholis. And unlike their role models, who have called Houston home since the mid-1960s, these astronauts live in Cocoa Beach. Production budgets dictated the fake address, but "there's also more of a romantic feeling about this area because of the early Mercury days," Antholis explains.

—Beth Dickey

PATRICK HERTZOG/AGENCE FRANCE PRESSE

Ariane 5 Fails

Arianespace's Ariane 5 heavy launcher was destroyed 40 seconds into its maiden flight from French Guiana last June ("The French Succession," Apr./May 1996). The launcher broke up at 13,000 feet when gimbals on the three rockets fully deflected, causing the craft to pitch and yaw wildly. Early investigations have targeted inertial guidance systems software that directed Ariane 4 but could not cope with the launch forces of the larger Ariane 5. The new launcher, Western Europe's largest and the United States' major competitor for commercial satellite launches, was not insured. The cost of the four international solar science satellites on board was estimated at $500 million.

Astronomy's Project Mercury

Before he enters the dome of NASA's Orbital Debris Observatory at Cloudcroft, New Mexico, project scientist Mark Mulrooney pokes a metal probe through a hole in the door, then checks a mercury vapor meter attached to it. "Zero-zero-zero," he says. "It's safe to go in."

At the center of the dome stands an eerie sight: a fist-sized hole in the primary mirror of one of the world's largest telescopes. If such a hole marred the Hubble Space Telescope, astronomers would wail and gnash their teeth.

Mulrooney is unconcerned. When your mirror is liquid mercury, a hole is easily patched. "We generally have to re-form the mirror every couple of weeks anyway to skim off the bugs and the dirt," he says.

The instrument is one of four liquid mercury telescopes in the world, and the first used for a major astronomical research project. This spring and summer, University of British Columbia astronomer Paul Hickson used it to categorize and measure the redshifts of several thousand galaxies. The survey, which he plans to continue next year, could help astronomers measure the expansion rate and the large-scale structure of the universe.

Hickson built one of the first liquid mirror telescopes in the 1980s. NASA decided to adapt the new technology to search for bits of orbiting debris that are too small or too stealthy to detect with radar. Orbiting junk could damage a shuttle or the space station, which will be assembled in orbit beginning next year. "You know you'll get hit—the question is when," says Mulrooney. "This instrument was built to pin down the answer."

NASA built the 10-foot telescope at the Johnson Space Center, but moved it to Cloudcroft in 1995 to escape Houston's murky skies. After a year of fine-tuning (and a moth-infested summer), Mulrooney says it is finally fully operational.

The telescope consists of a parabolic dish suspended on a finely balanced air bearing, rotating 10 times per minute. About two hours after it's poured into the dish, the liquid mercury locks into the same rotation rate and forms a perfectly shaped highly reflective two-millimeter layer across the bottom of the dish. The mercury soon interacts with oxygen in the atmosphere to form a thin crust atop the mirror, reducing levels of toxic mercury in the air to almost nothing (although in warm weather, scientists working around the telescope wear respirators with mercury filters).

Scientists search for space junk during twilight, when orbiting objects are still illuminated by sunlight. That leaves the middle of the night for astronomy. Astronomers could use the telescope for

galaxy surveys, and to search for supernova explosions and quasars. But since it cannot be tilted like conventional telescopes (lest the mercury puddle), it can only look directly overhead.

Hickson is designing a 16-foot liquid mercury telescope for construction near Vancouver that should be operational within two years. And if that works, he says, there will be no technical obstacle to a 30-foot or larger instrument.

"Astronomers tend to be pretty conservative with wild ideas like spinning tubs of mercury," he adds. "A lot of people are waiting to see if it works. The technology is still pretty young, and there are a lot of technical bugs to work out." And a few real ones too.

—Damond Benningfield

JOAN VITALE STRONG

New York City's College of Aeronautics used a Sikorsky Sky Crane to get three of its aircraft on campus last June. The school, which is located across the Grand Central Parkway from La Guardia Airport, airlifted a Beechcraft King Air, a Jet Commander, and Piper Seneca (shown above) to the campus parking lot with the helicopter. The Parkway was closed for 14 minutes while the Sky Crane made three trips, carrying the airplanes on a 200-foot line at about 100 feet off the ground. Students will use the aircxaft to study today's avionics and powerplant technology.

Air Traffic WYSIWYG

Last May the nation's air traffic control system took a small but significant step toward implementation of the Free Flight system, which would do away with defined traffic corridors in favor of a direct-to-destination flight plan (see "Goodbye Yellow Brick Road," Oct./Nov. 1995). A series of feasibility demonstrations, given jointly by the Experimental Aircraft Association, the Massachusetts Institute of Technology's Lincoln Laboratory, and the Federal Aviation Administration, showed off the capabilities of the Cockpit Display of Traffic Information in the high-traffic airspace off Long Beach, California.

Using a Global Positioning System receiver linked to a modified transponder, Lincoln lab developed software to enable Automatic Dependent Surveillance Broadcast (ADS-B), which allows aircraft to broadcast information such as identification, position, altitude, speed, and track. This information can be received and processed by other aircraft or ground systems for use in conflict avoidance and airspace traffic management.

The ADS-B is a high-speed all-digital system that automatically broadcasts detailed position information provided by the aircraft's GPS receiver. The packets of information are dubbed "squitters," a term that conjures up the short high-frequency digital bursts that replace analog voice transmissions.

With a 1090-Megahertz receiver and the appropriate software, a two-way (Mode S) transponder can monitor squitters and provide a pilot with a readout of local traffic as detailed as an air traffic control display. CDTI is one application of a broader FAA initiative known as Data Link, which is to properly equipped aircraft what the Internet is to personal computers: a backbone for the exchange of digital information.

"We purposely picked the most hostile environment we could think of for the demonstration flights," says EAA's Don Taylor, who flew his own Data-Linked Beechcraft Baron for the demo. "Between the transponder traffic, the ATC radar, and all the military radar in the Long Beach shipyards, this airspace is as crowded with potential conflicting radar signals as any in the U.S. If it works here, it will work anywhere."

Taylor flew several times along a preplanned course through the Southern California smog directly at a similarly equipped Bonanza flying at a slightly different altitude. The cockpit display consistently flagged the opposing traffic before it was in visual range. The difference in altitude of traffic is also displayed, allowing the pilot to discern potential conflicts.

All aircraft will have to be similarly equipped for the system to work. For general aviation aircraft, the cockpit display unit could easily be a laptop computer equipped with the display program. According to Gayle Thornton of the FAA's Data Link Program Office, the FAA is working to encourage acceptance of the new standard by demonstrating practical benefits to the general aviation community.

Once properly equipped, general aviation and the airlines would be on equal footing, with all aircraft having the ability to identify and track potential traffic, a key technology for the proposed Free Flight air traffic management system.

Taylor concedes that the entrenched procedures won't be changed until long after the technology is in place. "We are talking about a new term and a new role—air traffic management versus air traffic control—that will require substantial change in the role of controllers in the air traffic system," he says.

—Larry Lowe

UPDATE

Blues Leader Steps Down

Commander Donnie Cochran, "Boss" of the U.S. Navy's Blue Angels since November 1994, resigned the prestigious position last May, citing a lack of proficiency in his flying ("The El Centro Blues," Aug./Sept. 1992). The team canceled its next three airshows and more may be scratched. Last year the Blues were grounded for two weeks when Cochran felt his flying was not up to speed. Cochran flew the number-three left wing position in 1986 and 1987 and the number-four slot position in 1988, then returned in 1994 as commander.

NASA's Finishing School

Getting along with another culture is tough enough on Earth. Imagine living and working with a totally different culture in cramped quarters in low Earth orbit.

That's why the five-person crew of shuttle mission STS-81, scheduled to dock with the Russian space station Mir this December for a nine-day mission, recently got a crash course in communicating across cultures.

"Getting along with another culture means more than just learning about colorful costumes and interesting food,"

says Steven Jones of East-West Business Strategies, teacher of the day-long session. "Cross-cultural training includes a little anthropology, a little psychology, and a large dose of common sense."

The Harvard graduate has trained more than 2,000 NASA employees. "Culture is a barrier more important than language," he says. "When your cultural rules are broken, you feel angry, frustrated, and confused. The hard part is coming up with a strategy to deal with it."

In Jones' basic course (he also offers one on negotiation), he crams in an assortment of facts and hints about living and working with Russians, on Earth and in space. Students are introduced to Russian superstitions—never schedule anything important on the 13th, don't shake hands over a threshold. They learn about Russian hospitality and gift-giving, national holidays, and Russian diminutives. But the meat of the course attempts to define the Russian mindset. "The biggest obstacle in dealing with the Russians is thinking they are just like us," Jones says. But he adds that Russians handle time and information in a manner that is diametrically opposed to the way Americans do.

For example, Russians store every scrap of data, relevant or not, for possible future use. They network more and crave consensus. They view time as abstract and abundant, not something to be managed and organized.

NASA attorney Donna Baker discovered these characteristics during negotiations for an international space agreement. "Action items were not met and phone calls not returned," she says. "The Russians showed up late for meetings and then did not adhere to the agenda."

Thomas Rathjen, head of flight equipment research and development at the Johnson Space Center, had a similar experience. "We spent months negotiating with the Russians to select the food that will be served on the international space station," he says. "It's been a challenge, since they have different dietary baselines than we do. This course helped me realize there's another type of person out there, although it's hard to believe that anyone would not think time is important."

What students learn in Jones' class is to look for friction cues—feeling frustrated, bored, depressed, or emotionally asphyxiated. "Culture shock is exhausting," says Jones, "and it's easy to lose your perspective. When you feel it hit, slow down, think things through, and try to stay in an interpretive mode."

—Rita Cipalla

Picture Your Name...There

Last February, on its World Wide Web home page, NASA's Jet Propulsion Laboratory solicited signatures, offering to send them to Saturn on the Cassini probe in October 1997. JPL has since been inundated with postcards; well over 250,000 signatures have arrived from around the world, and the lab expects as many as two million. Volunteers from the Planetary Society are scanning them onto a CD-ROM. Send your autograph to Cassini Program, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109.

Jumping to Conclusions

Weighed down with a video camera and a bag full of gear, Scott Powers craned his neck and squinted skyward. "There—now I see them," he said as two of the Golden Knights, the U.S. Army's parachute demonstration team, materialized out of the overcast and streaked toward one another, colorful trails of smoke pouring from canisters strapped to their feet. "I just don't understand how anyone could have that much control when they're falling," Powers mused.

The Golden Knights were in the midst of five days of performances at the

CAROLINE SHEEN

Memorial Day Salute to Veterans airshow in Columbia, Missouri, last May. In a typical year the two Golden Knights teams, known for the intricate formations they create while falling and for pinpoint landing accuracy, may perform up to 70 times.

On Saturday morning the Knights assembled for roll call, then went through the maneuvers the nine of them would execute in a 120-mph freefall. Their boots scuffled across the tarmac as they locked arms and practiced one last time under the shadow of the jump plane, a Lockheed C-130 from the Missouri Air National Guard. "We do 'dirt-diving' before each jump so that everyone knows their place in the formation," says Corporal Brian Mayer, who is seven months into his three-year tour as a Knight. "There can't be any question in free fall because things go so quickly."

After the pilots demonstrated how the C-130 can leap off the runway in a minimal distance, the airplane leveled off and began circling the field while streamers were released to assess wind conditions. The jumpers talked and joked, flashing Hollywood grins while they chatted nonchalantly, even as the cargo ramp lowered and the rear of the airplane displayed a tilted panorama of Midwestern sky. Loadmaster Mark Woodhull wore a helmet and oxygen mask as he stood an arm's length from the edge of the ramp, now 12,500 feet above the target the Knights would aim for after they completed their formation. Occasionally a jumper would breathe off a free oxygen hose for a moment, then return to the jump preparations.

The Knights stood together, checked one another's gear, and got into position. High fives all around, confident strides toward the edge of the ramp...and then they were gone. The C-130 suddenly seemed hollow. Reporters in the rear of the airplane were told they could release their seat belts and move around until it was time to descend. "Don't get too close to the edge," Woodhull advised.

Back on the ground Mayer signed autographs. His team was already preparing for Monday's performance, in which they planned to jump over downtown Columbia and place jumpers in intersections a block apart. But a low overcast intervened. "It would have been a fantastic start to the parade," said spectator Mark Duehmig. "But that's okay. I'll be back next year."

—John Sotham

UPDATE

License Revoked

The Federal Aviation Administration has revoked the pilot's license of Jose Basulto, founder of the Cuban exile group Brothers to the Rescue (Soundings, Dec. 1994/Jan. 1995). Basulto was about to take off from Miami's Opa Locka airport last May 17 when he was served with an emergency FAA order rescinding his license. The FAA cited Basulto for violating Cuban airspace in July 1995 and last February, when two Cuban MiGs shot down two of Brothers' Cessnas, killing four people.

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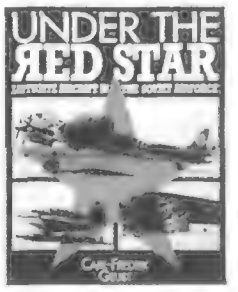

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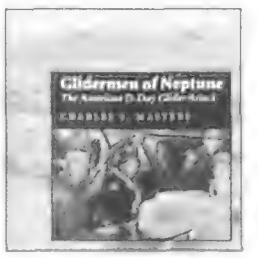

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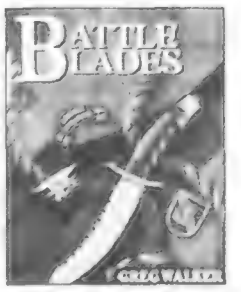

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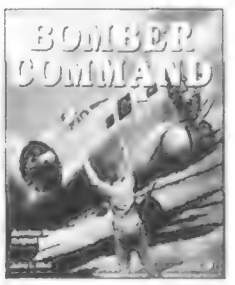

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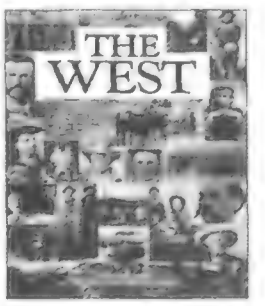

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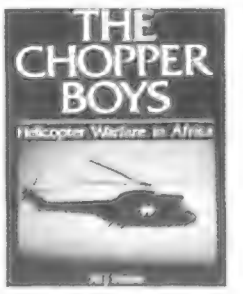

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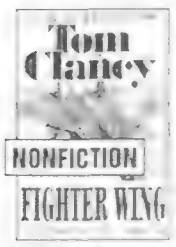

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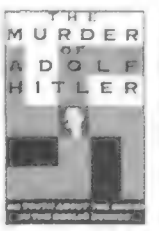

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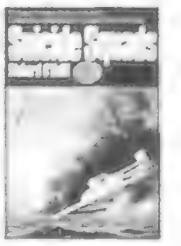

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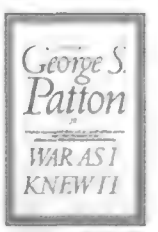

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The Do-It-Yourself Gallery

The only artifact that visitors to the National Air and Space Museum are encouraged to touch is a sliver of moonrock mounted on a stand in the Milestones of Flight gallery. And aside from a few artifacts that you can walk through, such as a backup workshop from Skylab and the forward fuselage of a DC-7, everything else is suspended just out of reach, roped off, or encased in plexiglass. "We're a hands-off museum—lots of priceless artifacts that nobody's allowed to touch," says curator Christopher Stetser. That long-standing policy will change on September 20, when the Museum opens "How Things Fly," a $3.4 million gallery that invites visitors to operate a supersonic wind tunnel, loft a helium-filled balloon, find out their weight on other planets, and, by all means, touch an airplane. They'll even be allowed to sit in the cockpit of a Cessna 150 and manipulate the flight controls.

By employing the hands-on and interactive techniques that science museums have been using for years, Stetser and designer Barbara Brennan have created a busy room full of things to manipulate and observe—a place both children and adults are encouraged to push, pull, slide, hoist, step, and climb their way through. "We are trying to explain some of the basic principles of flight to the broadest possible audience," says Stetser, who has spent six years working on the gallery, which is sponsored by Boeing and NASA, with additional support from the National Science Foundation. "We want to explain how the airplanes and the spacecraft in this building stay in the air and in space. We also want to explain why the airplanes and spacecraft in our collection look the way they do."

BRETON LITTLEHALES (3)

Skip Smothermon (above), Gary Fletcher (below, left), and David Cremer put the finishing touches on a gallery that curator Christopher Stetser and designer Barbara Brennan (opposite) have been working on for six years.

Visitors can move freely between the gallery's seven sections, which illustrate the forces of flight (weight, lift, thrust, and drag) with a surprising variety of mechanical devices, models, and touch-screen computers. There's a stack of bricks to represent the weight of the air in the gallery (about four tons), a radio-controlled blimp docked in an overhead hangar, an interactive computer program that shows pressure distributions over various wings, a gravity well, and much more.

The gallery's interactivity has, however, heightened concerns about visitor safety. "Whenever you have moving parts, you have to worry about pinch points," says Stetser. "You also have to protect the devices from the kids. You have to go through the mental chewing gum test: Imagine the worst possible place a kid could stick a piece of gum and cause hundreds of dollars' worth of damage, and then you have to design around that." A cutaway piston engine, for example, is covered with a see-through case, but visitors can operate it by turning a plastic

disk bolted onto the crankshaft where the propeller once was.

Because the gallery contains so many moving parts, it will employ a full-time maintenance person. There is also an upstairs office for a full-time gallery manager, and the Cessna Aircraft Company has funded an "explainers program," in which local high school and college students will wander around answering questions and otherwise ensuring a constructive interface between visitor and hardware. Stetser hopes that this unprecedented amount of oversight for a Museum gallery will keep everything in good working order.

"How Things Fly" should run smoothly, but certainly not quietly. "It will be a loud gallery," says Stetser. To muffle the din produced by the demonstration devices' motors and air blowers, Stetser is using rubberized motor mounts and copious amounts of acoustic foam.

Though "How Things Fly" is the most cacophonous gallery in the Museum, visually it is one of the most serene. Says designer Barbara Brennan: "I thought that the frenetic energy you find in some of these science centers really is counter-educational, and one of the guiding principles in coming up with the design was to try to keep it not agitated and just as calm as possible." She chose paint in restful shades of aqua, blue, and green and favored back-lighting over direct. To simulate the sky's expansiveness, she left plenty of open space and adorned one wall with a row of clouds carved from aluminum.

And wherever she could, Brennan sandwiched in chairs for people to sit and rest. But with a gallery that's so much fun, those chairs are likely to go unused.

—Diane Tedeschi

AT THE MOVIES

NASM/MOTOROLA FOUNDATION

On August 9, the National Air and Space Museum will host the world premiere of its latest IMAX film, Cosmic Voyage. *Employing a new filming technique called "Virtual Director," the makers of* Cosmic Voyage *used computer animation to simulate the explosive splendor of the Big Bang and the birth of the cosmos. Sponsored by the Motorola Foundation and the National Science Foundation, the film also includes footage shot in Europe, Hawaii, and Utah.*

The highlight of the 35-minute Cosmic Voyage *is a "cosmic zoom" through 42 orders of magnitude. Beginning in Venice, where Galileo crafted the telescope, the zoom moves viewers progressively outward, with each leap increasing the field of view 10-fold. After 26 leaps, viewers have journeyed some 15 billion light-years to the edge of the universe. The zoom then moves inward; traveling through increasingly smaller worlds, viewers move through the living kingdom in a drop of water and end the journey by looking at a quark. For showtimes and ticket prices, call (202) 357-1686.*

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700, Mon.–Sat., 9 a.m.–4 p.m.; TTY (202) 357-1729.

August 3 "Seeking the Stars." Astronomer John Miles describes his experiences studying starburst galaxies at two large U.S. observatories. Einstein Planetarium, 9:30 a.m.

August 16 "Model Airplanes on the Mall: A Workshop and Fly-In." Materials fee: $30 per child. To register, call (202) 786-2106 or TTY (202) 357-1505. Briefing room, lower level, 10 a.m. to 4 p.m.

August 17 "Blast Off! A Model Rocketry Workshop and Launch." Materials fee: $20 per adult, $15 per child. To register, call (202) 786-2106 or TTY (202) 357-1505. Briefing room, lower level, 8:15 a.m. to 4 p.m.

"Secrets of the Planetarium." Einstein Planetarium director James Sharp reveals how a planetarium projector produces special effects. Einstein Planetarium, 10 a.m.

Curator's Choice
Once a week a Museum curator will give a 15-minute talk about an artifact of his or her choosing. Aug. 7, Voyager spacecraft; Aug. 14, Voisin Model 8; Aug. 21, Wright 1903 Flyer; Aug. 28, Messerschmitt Me 262. Meet at the NASM Seal in the Milestones of Flight gallery, noon.

September 21 "Flying Toys Family Day." Designers of flying toys and boomerangs will explain how these objects fly. Entire Museum, 10 a.m. to 5 p.m.

September 23 & 30 "On the Wing: Animal Flight." Smithsonian experts on birds, bats, and insects will explain how these creatures fly. Gallery 109, noon.

On the Web

A World War II pilot tells his tale on the *Air & Space/Smithsonian* Website (www.airspacemag.com/TWD/TWD0002.html). Read an interview with Donald S. Lopez, who flew a Curtiss P-40 Warhawk with the 23rd Fighting Group in China. After the war he worked as a test pilot. Lopez is the deputy director of the National Air and Space Museum.

QUEASY RIDER

COURTESY WILLIAM P. KELLY JR.

In the early 1960s I was a flight and ground school instructor at the Navy's test pilot school in Patuxent, Maryland. On weekends I often carried the Parachute Club jumpers aloft in the school's de Havilland Otter, and I got to know the jumpmaster, R. J. Vasseur. Vasseur was a First Class parachute rigger and was also in charge of the Navy's Skyhook project.

Skyhook was invented by Robert Fulton, a descendant of the steamboat inventor. The intent was to parachute a small retrieval package to a crew downed in hostile territory. The package included a small folded blimp, a sphere of highly compressed helium for inflating it, 500 feet of strong plastic rope, and a parachute-like harness for each crew member. Upon retrieving the package, the downed crew would seek out a small clearing, maybe 20 to 50 feet in diameter. Just prior to a prearranged pickup time, they would inflate the blimp, strap into the harnesses, send the blimp up on the rope, and sit on the ground (or in a life raft) awaiting the rescue aircraft.

The idea was to lift rather than jerk a person off the ground—or out of the water—into a rescue craft, preferably a fairly high-speed, long-range airplane rather than a helicopter (which would be vulnerable to enemy ground fire). And the Navy, of course, wanted to use a carrier-based airplane. The original Navy tests had used a Lockheed P-2 land-based patrol bomber, and the Air Force had initially tried Skyhook with a Boeing B-17 bomber. The Air Force was developing an operational capability with Lockheed C-130 transports, and the Navy wanted a similar capability for retrieving downed airmen. Vasseur had already been lifted, but only in single-man configuration; now he needed someone to accompany him on a two-man lift. As a test pilot school instructor things were occasionally dull, so I volunteered.

The pickup aircraft was now a Grumman S-2A, a twin-engine carrier-based aircraft used for anti-submarine warfare. For the Skyhook project, the ASW gear was stripped out and the retracting radar dome removed from the

The writer (on ground left), a volunteer for the Navy's Skyhook project, and project director R. J. Vasseur snagged a ride on a Grumman S-2 the hard way (above).

belly, leaving a big hole for the lift line and "liftee." On the nose, a V-shaped hooking device would ensure that the lift line snagged the nose, not the propellers, and would guide the line to a locking device on the nose. A steel wire extended from each V tip to the wingtip on that side so that a miss wouldn't tangle the line around a wing. The S-2 would approach in level flight at 500 feet—just below the blimp—and about 125 mph, snag the line, and fly straight ahead to start the reel-in sequence after the liftees were well airborne.

The sudden tug of the line triggered a breakaway link at the attach point, freeing the blimp, which then disintegrated. The S-2 crew, stationed in the aft fuselage near the radar dome hole, would reach down with a hook, snag the pickup line (which by then would be trailing under the airplane), attach it to a hydraulic winch in the fuselage, and slowly wind in the dangling liftees through the radar dome hole.

The pickup subjects didn't wear parachutes, since an inadvertently opened chute would not only tear its wearer to shreds, it might also wreak havoc with the S-2. The S-2 crew could, however, attach a chute to the line and cut us free to parachute down in case the retrieval winch jammed.

Fulton's Skyhook was considerably different from the old airmail pickups, which snatched a pouch at low-level flight, and from today's banner pickups, which drag the banner off the grass. Since the S-2 grabbed the end of a 500-foot vertical line, there was no initial relative motion between the airplane and the liftees. Initial acceleration was very light, and initial movement was straight up (ideally through the clearing in the trees). Because of the line's mass and its air resistance, it would maintain a curved but changing shape rather than exposing the liftees to the sudden jerk of a straight line.

Vasseur was concerned with the liftee's ability to "fly" at the end of a 500-foot rope. He had experienced problems with this on his one-man lifts, and his concern was greater with two people on the same line, only 10 feet apart, and with me, a neophyte, above him. He had noted that it was easy to start spinning on the end of the line and throughout the reel-in. He talked me into a trial run: We would go up in the S-2, attach our harnesses, exit through the hole in the belly, and be wound out several hundred feet to practice our anti-spin tactics.

We maneuvered with our arms, with fists tucked into armpits or overhead, holding the harness riser straps, elbows sticking out. We made like ducks, using our folded arms as ailerons to counter twirl. You didn't dare let your whole arm fly free into that wind blast. We tried to fly face up, with the wind hitting our backs—if you got upside down or started twirling, a 125-mph wind blast in your facewas very uncomfortable and made breathing almost impossible.

March 24, 1964, was the big day of the two-man lift. Scrapbook photos show me sitting on the grass on the shore of the Chesapeake Bay with jumpmaster Vasseur. We were both strapped into our harnesses, the blimp was aloft in a strong west wind, and we were tied to the lift line. The S-2 came in from the east. When I couldn't see it anymore I knew it must be overhead, snatching the lift line. I was gently lifted from a sitting to a standing position, and then, with no jerk, I was going straight up. What an acceleration from vertical to almost horizontal flight! We were airborne, way above ground level, at the bitter end of a long length of oversize clothesline.

I was the upper man on the totem pole, an obliging gesture on Vasseur's part. He put me 10 feet above his head, where he couldn't see me (you didn't dare tilt your head back to see what was above you—you could start twirling or even break your neck). I guess he figured if I was higher, I was less of a danger, and less likely to get the both of us spinning.

The wind-in with the low-power hydraulic winch seemed to take forever; actually, it was something like 20 minutes. We "flew" almost half the length of the Chesapeake Bay before finally reaching the S-2. It was a real strain to "duck fly" with our elbows to keep level and face up. Even breathing was a chore: At that airspeed, the wind seemed to suck the lungs empty. If we got positioned face down or started spinning, the wind blast would begin to pressurize the mouth, throat, and lungs, and it was nearly impossible to exhale.

The worst part was the final segment of the wind-in, as the winch dragged us against the airplane's belly to the radar dome access hole. We had to be face up and stable to fend off contact with the airplane and to position ourselves for entry through the access hole. I still recall how hard the airplane skin was and how sharp the rim of the hole. We were wearing helmets and dummy oxygen masks for wind protection and I had on long johns, a standard flightsuit, and a heavier set of coveralls with a hooded parka. When I finally got inside the airplane, I was pooped.

We should have been half frozen after that lengthy wind-in: Imagine the wind chill in March. But I don't remember any sense of cold until I got aboard the S-2. Then I got a good case of the shivers, and perhaps that wasn't due only to the air temperature.

I had managed to keep my Skyhook role secret from my commanding officer, the director of the test pilot school, until just after our successful two-man lift. Then he received several calls about his daffy instructor and called me into his office. "Why did you do this without informing me?" he asked. "Well, Captain," I said, "if I had asked permission, you probably would have said no. And if I had gone ahead with it, that would have been direct disobedience of orders." My wife had received several calls by then, and my reception at home was just as frosty.

I have no information on what operational use the military made of Skyhook—it was a rather highly classified matter at the time. As far as I know, the Navy made a few more tests but never used the system operationally. But I do know that the Air Force maintained their Skyhook capability through the Vietnam war, so I imagine that a few clandestine pickups have been performed. I still have the Fulton plaque on my "brag wall," evidence of a daring but certainly dumb stunt.

I hope that any later liftees knew how to fly like ducks—and that they had an obliging flight surgeon aboard to provide a swig of that rotgut the military called medicinal brandy to calm the shivers.

—William P. Kelly Jr.

Kelly keeps the Fulton Company plaque on his "brag" wall, "evidence of a daring but certainly dumb stunt."

Oh, I have slipped the surly bonds of earth [1]
And danced [2] the skies on laughter silvered wings;
Sunward I've climbed [3] and joined the tumbling mirth [4]
Of sun-split clouds [5]—and done a hundred things [6]
You have not dreamed of—Wheeled and soared and swung [7]
High in the sunlit silence. [8] Hov'ring there [9]
I've chased the shouting wind [10] along,
and flung [11] my eager craft through footless halls of air.
Up, up the long, delirious, [12] burning blue
I've topped the wind-swept heights [13] with easy grace
Where never lark, or even eagle [14] flew.
And, while with silent, lifting mind I've trod
The high untrespassed sanctity of space, [15]
Put out my hand, [16] and touched the face of God.

—John Gillespie Magee Jr., 1941

The Annotated *High Flight*

Federal Aviation Administration notations, 1996

1. Flight crews must insure that all surly bonds have been slipped entirely before aircraft taxi or flight is attempted.

2. During periods of severe sky dancing, the FASTEN SEATBELT sign must remain illuminated.

3. Sunward climbs must not exceed the maximum permitted aircraft ceiling.

4. Passenger aircraft are prohibited from joining the tumbling mirth.

5. Pilots flying through sun-split clouds must comply with all applicable visual and instrument flight rules.

6. These hundred things must be listed on a Federal Aviation Administration flight plan and approved prior to execution.

7. Wheeling, soaring, and swinging will not be accomplished simultaneously except by pilots in the flight simulator or in their own aircraft on their own time.

8. Be advised that sunlit silence will occur only when a major engine malfunction has occurred.

9. "Hov'ring there" will constitute a highly reliable signal that a flight emergency is imminent.

10. Forecasts of shouting winds are available from the local Flight Service Station. Encounters with unexpected shouting winds should be reported by pilots.

11. Be forewarned that pilot craft-flinging is a leading cause of passenger airsickness.

12. Should any crew member or passenger experience delirium while in the burning blue, submit an irregularity report upon flight termination.

13. Windswept heights will be topped by a minimum of 1,000 feet to prevent massive airsickness-bag use.

14. Aircraft engine ingestion of, or impact with, larks or eagles should be reported to the FAA and the appropriate aircraft maintenance facility.

15. Air Traffic Control (ATC) must issue all special clearances for treading the high untrespassed sanctity of space.

16. FAA regulations state that no one may sacrifice aircraft cabin pressure to open aircraft windows or doors while in flight.

—Author Unknown

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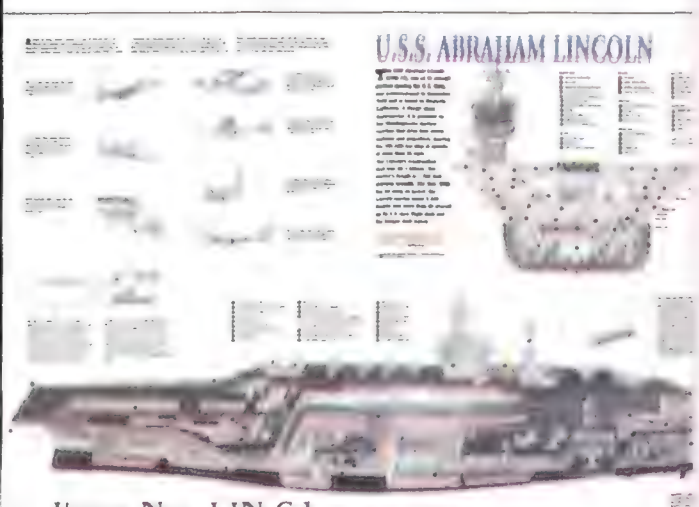

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The roar of their rotor blades
shakes your windows.
Their blinding spotlights stab
through the darkened skies.
It's a scene repeated
night after night
in cities across America.

THE HELICOPS

by Carl Hoffman

Photographs by Chad Slattery

The helicopter beat is a prestigious one, allowing the officers to remain isolated from the grittiness of street crime.

It's Saturday night, and a Bell JetRanger is throbbing 500 feet over the City of Angels—a wasteland of asphalt rooftops and white concrete and freeways stretching in every direction. From up here, Los Angeles is a lit-up grid of shopping malls and lookalike housing. Over the radio comes a staccato narration, terse stories of a city on the edge of chaos.

"Code 37, Olds Cutlass, brown," crackles the dispatcher's voice. A stolen car has been spotted cruising the streets.

"Roger," answers John Mardesich.

Below, three patrol cars are following a brown Cutlass. The Cutlass cruises slowly for a block, turns nonchalantly at an intersection, and bolts.

Mardesich turns on the Nightsun, illuminating the fleeing car with a 30-million-candlepower beam. One block, two blocks—the JetRanger is flying 80 mph and it's just keeping up. The horizon tilts to the left, to the right. Inside the helicopter there's a faint whiff of fuel.

"You have cross traffic," Mardesich radios the pursuing officers on the ground. The Cutlass is half a block ahead. It careens through an intersection, jumps the curb, and jerks to a stop on someone's lawn. Two men vault from the car and flee in opposite directions.

Brandt yanks the JetRanger into orbit. The patrol cars stop; officers swarm. A suspect races down the street, leaps a fence, cuts across a back yard, leaps another fence, climbs onto a garage roof. "He's on the roof, he's on the roof!" Mardesich yells into the mike.

For the suspect, it's a nightmare: The JetRanger is directly overhead, its noise overwhelming, its Nightsun exposing him like an actor on a stage. He can hear his every move recounted over the helicopter's public address system.

His hunters close. He leaps into a yard, climbs a fence, reaches the roof of what appears to be a fenced-in porch. Then he is tackled.

John Mardesich serves as an observer, guiding the pilot to the crime scene and communicating with the officers on the ground.

After a flight, pilots in Los Angeles use ropes to secure the rotor blades to the airframe (below).

Opposite: Arriving over a burglary in south central Los Angeles, an observer directs ground units to establish a perimeter of officers that will seal off an eight-block area.

Serving as the pilot's observer, he wears a regulation green military flightsuit, handgun, black combat boots, and white helmet. From under his seat he pulls out a street atlas.

Pilot Jack Brandt pushes the cyclic forward. "I'm coming, buddy; I'm maxed out," he says to himself. The helicopter's nose drops and the JetRanger surges forward. In seconds it's blasting across the city at 120 mph, shaking like a blender. Streets, rooftops, railroad tracks, anemic palm trees race by.

"Okay," Mardesich says to Brandt over the intercom, pointing to the left and counting the streets out loud. "It should be right about here."

The helicopter rolls into a tight, nauseating orbit at 60 mph. It's banked so steeply that to gaze at the ground you just look out the window.

Today there are more than 300 police aviation units in the country—enough so that nearly every major U.S. city's police department either has its own or can call on a neighboring one for help. If you live anywhere near a big urban center, chances are you've seen or heard one. If you're lucky, your encounters weren't as unpleasant as mine.

For 10 years I lived in a Washington, D.C. neighborhood that real estate agents liked to say was undergoing "gentrification." Really, it was a ghetto. By day I would look out my home office window and watch characters wearing wool gloves in 95-degree heat carrying television sets and VCRs in and out of the local crack house. By night we listened to the *tat-tat-tat* of automatic gunfire. And the clatter of helicopters circling low.

Summer nights were probably as close as I'll ever come to experiencing the sounds of Vietnam. Police helicopters seemed omnipresent, their searchlights beating through our windows, the noise rattling glass, drown-

Putting Together a Squadron

Bell 206 JetRangers and McDonnell Douglas 500s have long been the staple of police helicopter divisions. But as police helicopters carry ever more gear, cover more ground, and chase ever faster cars. those old workhorses are proving too weak and slow. The Los Angeles Police Department's air support division is phasing out its JetRangers. Says Captain John Trundle: "You take a 210-pound pilot, a 210-pound observer, a 210-pound passenger, a full load of fuel, and a hot summer day and you can't get off the deck."

Finding a replacement is a matter of balancing often contradictory requirements. Naturally, Trundle wants the fastest helicopter he can get. He also wants one big enough to lift 600-odd pounds of officer, a LoJack stolen-car recovery system, a Forward Looking Infrared system, a Nightsun, and a full aviation and police communications package, with room to spare. But, to keep down operating and maintenance costs, he wants no more than one engine. And, says Trundle, the helicopter has to be small enough to "jerk around" in tight orbits over crime scenes. It has to be as quiet as possible and efficient enough to complete a two-hour mission with fuel to spare.

Like many in airborne law enforcement, Trundle is intrigued by the McDonnell Douglas MD 520N Notar. It's similar to the MD 500, but instead of a tail rotor it has a hollow tail boom; pressurized air passing through the boom provides directional control. "Because 25 percent of helicopter accidents are caused by tail rotor strikes, they are safer," says Lieutenant Mike Casey of the Phoenix, Arizona Air Support Unit.

The MD 520 is also more powerful than the MD 500 and capable of operating at a higher altitude and taking off at a greater maximum weight. And according to certification data from the Federal Aviation Administration, the MD 520N is the quietest turbine helicopter on the market. Today, more than 70 are serving with law enforcement agencies.

ing out "Seinfeld," waking our baby.

I never got the impression they made a difference. In all the crime stories in the *Washington Post*, I never read that a helicopter had caught someone. And whenever I looked out the window, the drug dealers and hookers on the corner were still plying their trades.

I decided to call a couple of police departments with big helicopter operations and get their side of the story. Two of the nation's biggest police aviation units, Los Angeles and Houston, agreed to let me ride along with them for a few days.

Los Angeles shimmers like a video game screen. The police department has divided the city's 430 square miles into thirds, and 20 hours a day, 365 days a year, each section is patrolled by a helicopter.

It's nearly midnight. The helicopter pitches and rolls, one moment flying slowly and aimlessly as if lying in wait for game, the next ripping away at maximum speed to answer a call. Larry Pope is the pilot, Jorge Gonzales the observer. Pope scans the crowded skies, looking for other aircraft, avoiding buildings and the deadly snares of antennas, power lines, even a child's kite. (All LAPD helicopters are equipped with wire-strike protectors—rubber-coated hack-saw blades protruding from the top and bottom of the helicopter's nose.) Gon-

Helicops—A History

When law enforcement departments first turned to aircraft, they weren't thinking of bad guys. After an earthquake rocked Long Beach, California, in 1933, Los Angeles County sheriff Eugene Biscailuz created a squadron of private pilots flying their own airplanes to aid in searches and rescues. New York City put together its aviation squadron in October 1929 with a Loening Commuter and a Savoia Marchetti. "We did photographic work, traffic surveys, and a lot of Coast Guard-type work," remembers Captain Gus Crawford, the world's first police helicopter pilot, now 87.

In 1946 the Civil Aeronautics Board granted the first certification for a civil helicopter: the Bell 47G. "People were talking about using helicopters in the city for all kinds of things, like delivering airmail, but no one knew a thing about them," says Crawford. New York sent him to Bell headquarters in Buffalo to find out. A month later he returned as a licensed helicopter pilot and instructor, as well as a convert to the new technology. "I used to fly Mayor O'Dwyer around in the police department's Grumman Goose," he recalls. "One day he asked me if there was anything I needed. 'I want a helicopter,' I said."

The world's first police helicopter, a Bell 47 on floats, arrived in New York City in 1948. "I thought it was a pretty good machine," says Crawford. He was impressed with its reliability: "You could fly a helicopter in nearly any kind of weather and they were real maneuverable. We followed cars all over the city for the vice squad, rescued kids trapped on thin ice, spotted fires, and found cars buried in the swamps of Brooklyn and Queens." The helicopters worked so well, he remembers, that the department got three more.

In Los Angeles, the police department bought its first helicopter, a Hiller 12-C, in 1956 to help its traffic enforcement division patrol the city's freeways. It wasn't until 1965, when the community of Watts rioted, that the LAPD first used helicopters to help fight crime. "The riots were so colossal in violence and scope it's hard to even explain," says Leon Owens, one of the city's first police pilots. "There was a lot of ground fire and the National Guard and police had trouble moving around. We operated as a platform directing the troops and police."

Soon after, the city asked Officer Jim Beall to evaluate helicopters for routine police patrols. "I said it was an effective tool in major unusual occurrences and discreet surveillance," Beall recalls, "but for patrol work it would be a waste of money. You had an incredible field of view—you could see all these ants moving around—but I just didn't think you could see enough detail for police work." Quickly, however, Beall learned that with practice, "you could stop looking at the panorama and start focusing on individual cars or people." He eventually helped to create what's now the department's air support division.

Over the years the LAPD has become so reliant on its helicopter force that today, says aviation patrolman Mat Jaroscak, "to police L.A. without helicopters would be virtually impossible."

The LAPD's Hooper Heliport is the largest rooftop heliport in the world (left).

Mounted on the chin of this LAPD AStar is a heat-detecting FLIR—a forward-looking infrared sensor. To prevent wire strikes, police helicopters brandish spikes just above their windshields.

zales monitors two radio frequencies: a city-wide broadcast of high-priority crimes and the frequency of whichever of the city's 17 patrol divisions they are overflying. He is selective about what calls to respond to—mostly hot pursuits, property crimes, and burglaries that have just happened and in which there's a detailed description of a fleeing suspect. And, of course, any call involving an officer in trouble.

His eyes scan the ground. The JetRanger churns over a back yard alive with blinking lights, streamers, people dancing; a basketball game at a park; the crowded commons of a public housing project.

I remember the deafening noise at my old house; I used to wonder if they buzzed as long and low over ritzier neighborhoods. Up here it seems a distant concern. These guys are thinking about criminals, not sleeping babies. "People complain about the noise occasionally, but you can't make everyone happy," says Gonzales. "While it may be true that they can't sleep while we're over their heads, the question is: Are they willing to sleep if we don't pin the suspect down?"

I come to realize that the noise produces an atmosphere of omnipotence and omnipresence around the helicopter, and that the craft is used not just to apprehend but to intimidate and suppress. Anecdotes abound, especially one told by police aviators almost as universally as some aboriginal creation myth: A woman is about to be raped. Suddenly the rapist hears the *whomp-whomp-whomp* of a helicopter. He flees. The sound, it turns out, is merely that of a television station's traffic helicopter.

Still, because poor neighborhoods have more crime, they bear the brunt of police helicopters' efforts at crime suppression. One afternoon a helicopter team races to a public housing project where "gang members harassing motorists" have been reported. When we arrive there is no sign of anyone, but the pilot decides to linger over the area anyway, "shaking the roofs," as the ob-

Observer Glen Lampton (at left) uses gyro-stabilized binoculars while Rick Holtsclaw flies the MD 500 over Houston. The McDonnell Douglas helicopter (below) has an appropriately authoritative bearing.

server puts it, in a show of force. On another night we are called to a shooting in a middle-class neighborhood. When we arrive a haze covers the area. "This is a noise-sensitive area," pilot Bill Anderson says. "Let's not go in there. We'll have to be real low and we'll wake some people, probably even get a complaint."

Gonzales and Pope race to a car stripping in progress. At his fingertips Gonzales has gyrostabilized binoculars, the Nightsun searchlight, a P.A. system, a LoJack stolen-car homing device, and a heat-sensitive forward-looking infrared (FLIR) camera and monitor that in the blackest night can pick up a rabbit running through a field from an altitude of 500 feet.

Sitting in a trash-strewn alley is a red pickup truck, already picked apart.

A block away, Gonzales sees a man walking "too nonchalantly with a purpose." A patrol car arrives and Gonzales makes contact, directing the officer to the suspect. He is confronted, frisked against a wall, handcuffed, and taken away.

Gonzales and Pope are police officers, as are most police helicopter crews around the country. All are veterans of their police departments and veterans of patrolling their city's streets. The LAPD requires officers to work a minimum of five years on the streets of Los Angeles before becoming eligible for aviation duty; Houston requires four years. Most crews have much more. They know the city's alleys, its convoluted gangs, its neighborhood idiosyncrasies like only a local patrolman can. They know what to look for at a crime scene. They know what a "copper," as they sometimes call them, fears. And they know they don't want to go back to any of that. "We're kind of isolated up here," Gonzales says as the ship resumes its patrol. "We don't have to deal with the criminals on a personal basis. The ground handles the bodies and paperwork. We just fly away."

The impersonal nature of helicopter patrolling is one of the attractions of the job. "I don't miss being pushed around, spit on, or getting complained about" by suspects, pilot Rick Holtsclaw told me a few weeks later in Houston.

Crews do regularly see flashes of gun muzzles and occasionally hear from citizens reporting sparks flying off the helicopters. Gonzales says, "It's rare that they actually hit the ship," but three years ago Holtsclaw was flying when "some old boy got out of his car and fired five rounds. It shattered my bubble, hit my observer in the head, and went into my rotor head." (The Houston police won't give out further details about the incident, fearing that recounting the story will compromise officer security.)

And during the riots that broke out in Los Angeles over the verdict in the Rodney King beating, crews flew sitting on bullet-proof vests. "There was complete lawlessness," says Mardesich. "Smoke restricted visibility and the

ground was covered with fireballs."

Still, Holtsclaw calls air support duty "the best job a patrol officer can have." It is prestigious and competitive. In both Los Angeles and Houston, the police department pays for all flight training through a commercial rating. Unlike a simple commercial course, however, police training emphasizes crew coordination, landing on inclines and rooftops, and emergency landings. "Our emergency training is very pro-active, just like the military's," says Ira Putnam,

L.A.'s chief pilot. The trainees, he adds, repeatedly practice a life-saving technique called autorotation. This procedure enables the pilot to land safely after an engine fails. In such instances, the pilot quickly lowers the collective control that adjusts the rotor blades' pitch, meanwhile flying forward and descending at an angle that ensures that airflow through the rotor will cause it to rotate on its own. When the helicopter nears the ground, the pilot increases pitch by raising the collective control, and the momentum of the rotor blades provides enough residual energy to slow the descent and allow a soft landing. The trick is to coordinate all this activity while locating a spot to land on.

And after five to six months of training, Holtsclaw says, "they give you a million-dollar helicopter to fly. Then we get to pick the calls and chase bad guys."

The air over Houston is as hot and thick as steam, so the McDonnell Douglas 500 helicopter flies without doors. Rick Holtsclaw is the pilot; Glen Lampton the observer. Below stretches the city's 580 square miles, covered at any one time by just two helicopters.

Across the radio comes a report of a burglary in progress. "What's the address of your burglary?" Lampton asks, pulling out his atlas. Holtsclaw banks hard to the left, the nose dips, the ship races. The dusk is blue-gray. The smell of pancakes blows by. One moment Holtsclaw is cutting over an urban pinball machine of neon lights, the next banking over green fields and herds of cattle.

The name of the game in helicopter policing is to be on top of a crime scene fast, long before a patrol car, so the flying is aggressive and characterized by rapid power changes. "We do things that most helicopter pilots never get to do," says Holtsclaw. "I've got to get my observer down so he can see. Yet I've got to fly the helicopter so I can keep it safe and maintain rotation in a way that doesn't get him sick. You can trim out an airplane and it will fly itself. But the only thing a helicopter wants to do is kill you. And at night with the spotlight on it's real easy to get tunnel vision."

The dispatcher radios: There are al-

ready enough units on the scene of the burglary. The call is canceled.

It's a slow night. Holtsclaw and Lampton criss-cross the city at 600 feet, checking alleys and fields for abandoned cars. They're called in to check a few rooftops for prowlers. Nothing. A patrol officer asks them to look for a black car that's already 15 minutes away from the crime scene. It's hopeless. The more they search, the more black cars they see.

"Our success rate isn't that great," admits Holtsclaw. "This city has too much ground clutter, is too big, and there are too many places to hide. We want to back up our officers, and it's disappointing because sometimes we can't find people.

"We're trying to get a FLIR system but the funds are lacking," he says. "We can't understand how the city can pay $800,000 for one of these [helicopters] but won't pay another $100,000 for a piece of equipment that would help us at night."

Still, says Holtsclaw, even without FLIR, helicopter cops can perform a service. "We watch the [ground] officer's back and lay down a path for him to work," he says. And officers on the ground appreciate the helicopter's shouldering its share of the danger. "Helicopters allow us to back off, and that saves us and innocent bystanders," says Officer R.J. Morgan, a 20-year veteran of Houston's streets. "I've chased suspects at 120 mph until the helicopter arrives and takes over. At that speed there's no way to control the vehicle and there's no telling what could happen." In 1991, after a series of fatalities occurred during car chases through Washington, D.C., the city severely restricted police car pursuits. "A bank robber could be speeding by and we just let 'er go," says officer Ronald R. Robertson. "Choppers are the only way we can chase them."

Helicops cruise over all areas of Houston, from business districts (left) to freeways (the photo below shows a stolen car being stopped).

Skeptics like me might spout off about the noise and the intrusiveness, but for the most part, the public seems to accept the idea that the police must maintain helicopter squadrons. Other than occasional protests in rap songs or Big Brother characterizations in films like *Boyz in the Hood* and *Grand Canyon*, you hear far more complaints about crime than you do about police helicopter patrols.

"I haven't heard anyone complain about police helicopters," says Calvin Naito, spokesman for L.A. City Coun-

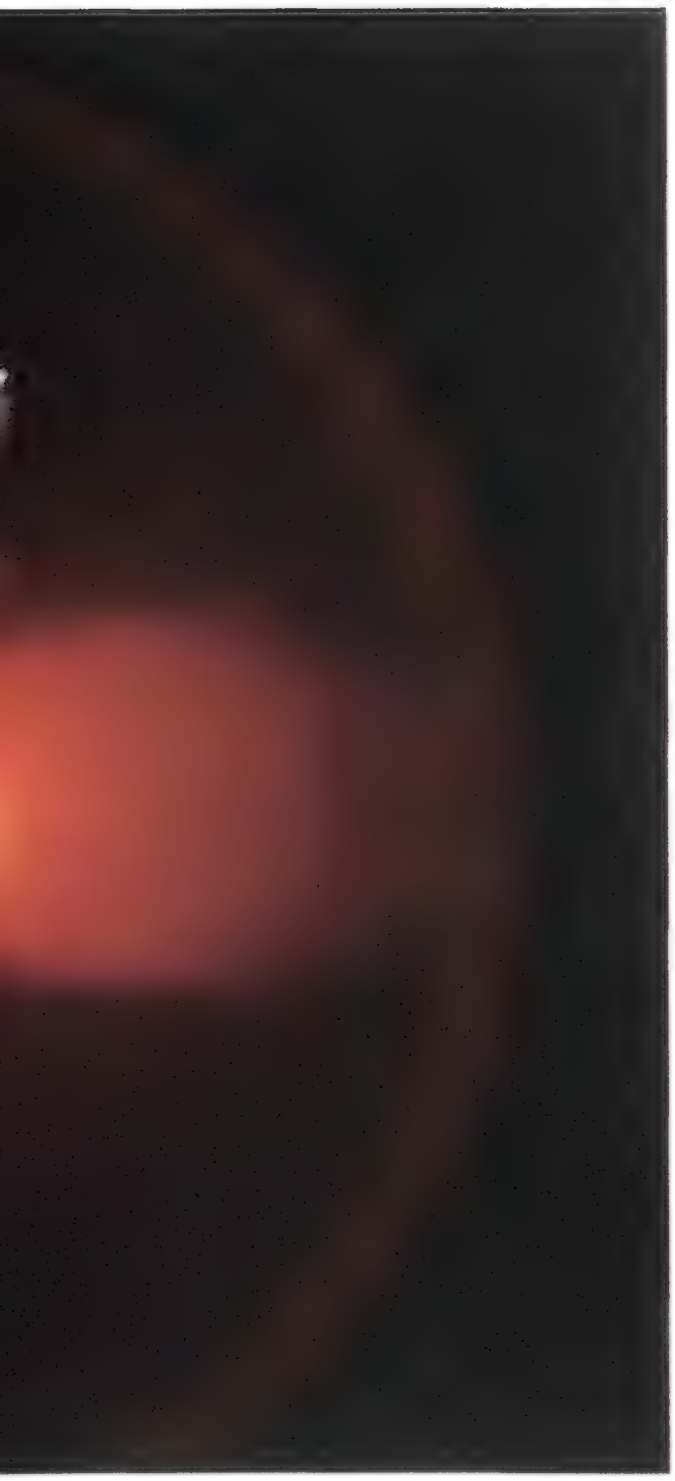
cilman Mark Riddley Thomas, who represents a low-income district. "Riddley Thomas' constituents are as much for public safety as anyone else in the city."

"The public has come to realize that a helicopter overhead is probably fighting crime," says Eric Rose, a spokesman for Los Angeles City Councilwoman Laura Chick. It was Chick who last year sponsored a motion to replace three retiring police helicopters at a cost of $4.8 million, even though the city was facing a billion-dollar budget shortfall. (The motion passed without dissent.)

What is this faith based in? There has not been a major independent study of the effectiveness of helicopter policing in over 25 years. And of the two studies that have been conducted, neither was strongly conclusive.

In 1966 the federal Law Enforcement Assistance Office and Hughes Tool Company's aircraft division, the manufacturer of Hughes helicopters, teamed up with the Los Angeles County sheriff's department and the city of Lakewood, California, to carry out Project Sky Knight, a study of the effectiveness of helicopters as airborne patrol vehicles. (Hughes donated three Hughes 300 helicopters for the study.) Twelve months and 3,100 hours of flying time later, the answer was in. Sort of. A helicopter cost 18 times more than a patrol car to purchase and nearly four times more per hour to operate, but according to the study, it enabled the city to handle an average of 25 percent more cases than it had the year before, when it had no helicopter. And while two "demographically similar" California cities experienced crime increases of over 20 percent during the same period, Lakewood's crime dropped nearly nine percent. The study had no true control, however, and without one there is no way to be certain if Lakewood's crime drop had anything to do with the helicopters.

Apparently unconvinced by the Sky Knight study, Los Angeles set out to prove their worth for routine patrols by commissioning a study by the Office of Space Technology Applications at Pasadena's Jet Propulsion Laboratory. The 1970 report concluded that in the areas where helicopters were tested, property crimes were "significantly lower," and that "no other changes within the police system [except helicopters] were found that could account for these results." But a close look at the report shows that the data were all over the



place, with crimes and arrests decreasing in some areas and during some parts of the year but remaining unchanged in others.

A more revealing finding was that "89 percent of the total sample of residents support the continuation of helicopter patrols in both test divisions." In their ranking of negative characteristics, the report said, respondents "placed invasion of privacy very low." Perhaps this is the tragedy: that urban life has deteriorated to the point where people will tolerate the intrusiveness of a helicopter clattering over their roofs in return for a feeling of safety.

Tonight a layer of mist is seeping into Los Angeles. Larry Pope and Jorge Gonzales are in hot pursuit. Below them, four men are fleeing a robbery armed with a shotgun, winding in and out of heavy freeway traffic at speeds of nearly 100 mph.

"Larry, gas it, GAS it!" Gonzales yells, in between directing the officers pursuing on the ground and keeping the suspects under his searchlight. "Okay, he's coming up to the 110 split. Larry, come around, left, left. He's hauling ass! Okay, you're doing fine." The suspects dodge cars, swerve onto the shoulder, fly down an exit ramp. "Okay, he's committed to 10," Gonzales directs. "Okay, he's westbound on 10, coming up on Alameda. Larry, Larry, he's losing us. Watch out for the Bendix building—it's close."

The car exits the freeway and whips down a street and into the fog. Pope jerks the helicopter up and around. "I'm not going into that," he says.

A few minutes later the radio reports that three of the four are captured. A dog will hunt down the fourth.

Fly with the police for a few hours and it begins to seem routine, like watching a movie: the noise, the power, the yanking and banking between buildings and over back yards, a never-ending tale of robberies, assaults, fights, thefts, injuries, and injustices proliferating like cancer. After a while it's easy to think of the million-dollar flying machine outfitted to chase down and apprehend criminals as just another municipal tool.

I've moved now, an escapee to a suburb. It's quieter here, and police helicopters don't come too often. But should they ever return and start orbiting near my house, I suppose I'll still grouse about the noise. Then I'll check the kids and bolt the doors.

PHOTO BY DAVID SLADE, HOUSTON PD

Searchlights give police helicopters an aura of both omnipotence and omniscience.

One of the most exciting images recorded by the Hubble Space Telescope is known as the Hubble Deep Field (HDF), a composite of 342 exposures taken last December. With the aim of learning more about distant galaxies, scientists on the HDF team, led by Space Telescope Science Institute (STScI) director Robert Williams, chose a relatively uncluttered piece of sky near the handle of the Big Dipper and kept the Hubble's Wide Field and Planetary Camera 2 trained on it for 10 days straight. Exposures typically lasted from 15 to 40 minutes and were recorded in four wavelengths: ultraviolet, indigo, orange, and infrared. As scientists at STScI processed each exposure, they stacked them into a composite picture; each time they added a frame, the view deepened, revealing fainter objects.

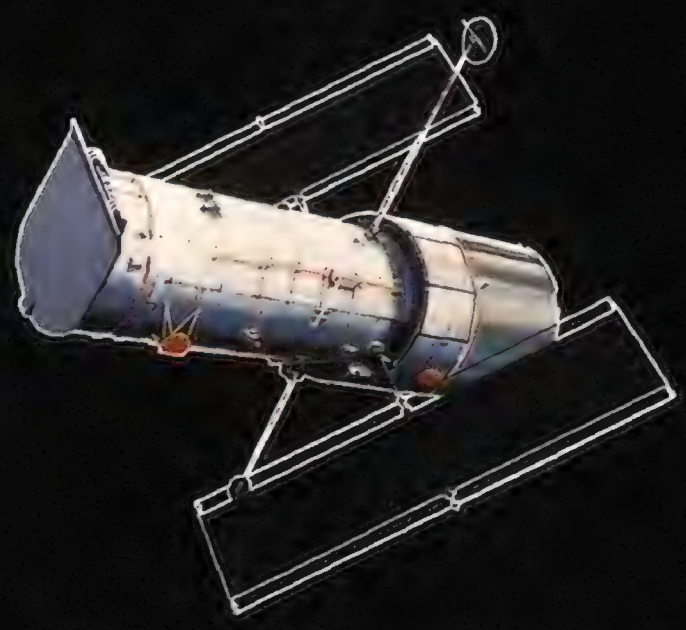
In width, the Hubble Deep Field spans only a small speck of sky, but in depth, it stretches back billions of miles toward the visible horizon of the universe. Think of it as an extremely long core sample of the heavens, one that is chock full of visible objects. In fact, the HDF has turned out to be a celestial gold mine, revealing at least 1,500 galaxies in various stages of evolution. "It's like looking down a long tube and seeing all the galaxies along that line of sight," says HDF team member Mark Dickinson. "They're all stacked up against one another in this picture and the challenge now is to disentangle them."

Some of the galaxies visible in the HDF are the faintest ones ever seen by a telescope (nearly four billion times fainter than what the human eye can detect). And what has generated great excitement in the astronomy community is the likelihood that some fraction of these galaxies date back to the time when the universe was less than a billion years old. Astronomers will be studying the HDF data for years to come, and their expectations are high. "In time, these Hubble data could turn out to be the double helix of galaxy formation," says HDF team leader Robert Williams.

ROBERT WILLIAMS/STScI/NASA

SPLENDOR IN SPACE

THE VIEW FROM THE HUBBLE
PART II



Taking beautiful pictures with the Hubble Space Telescope is nice work if you can get it—and you can get it if you try.

by Tony Reichhardt

captions by Gerrit L. Verschuur

Given the chance to look through the world's most powerful telescope, what would you look *at*? The dim and the distant, of course. Those things that are suspected but not yet seen. Exactly what, though?

For Robert Williams, using the Hubble Space Telescope to peer deeply into the universe back to its horizon was a "no-brainer," an experiment that somebody had to do sooner or later. Point the space telescope at an apparently empty patch of sky, take a long exposure, and see what turns up. When Williams first proposed the idea, though, not everyone was bowled over. "There were a lot of people who criticized it," he says. "They thought it might not yield very many scientific returns, and that the time could be used better."

As director of the Space Telescope Science Institute (STScI) in Baltimore, which administers the operation of the Hubble, Williams has the right to claim a small percentage of Hubble's viewing time for his own projects. To be fair, though, he asked an outside panel to decide if his idea had merit. He never doubted the answer would be yes. "To me it was *the* compelling thing to do," he says. His hunch proved well founded. The image that he generated last December, known as the Hubble Deep Field, has revealed a timeline of ever fainter galaxies stretching back to the universe's beginnings.

Not everyone has such privileged access to astronomy's crown jewel, of course. The scientists who helped build the telescope or its instruments are guaranteed some viewing time, but everyone else has to stand in a long line for "Guest Observer" slots. Last year more than 1,000 wanna-looks sent in proposals. Two out of three were turned down—an improve-

Within our own galaxy, only 7,000 light-years away, the act of star formation is revealed in vivid detail inside the monstrous Eagle nebula, designated M16. Here vast tongues or elephant trunks of cold gas and dust envelop embryonic stars, while ultraviolet light from nearby hot stars (out of the picture at the top of the image) heats and eats its way into the protective nebula. At their exposed surfaces, the elephant trunks—the largest one here is six trillion miles, or one light-year, long—evaporate, which causes the fuzzy appearance at their tips. If you look closely just below and to the right of the bright star whose light has produced six rays (an artifact generated by internal reflection in the HST), you'll see what looks like a flame atop a thin candle, which is a star that has just been exposed. Another star prematurely revealed by the evaporation of its dusty cocoon glows faintly at the tip of the tongue of dust directly to the left of the bright star.

"What we're seeing here is the process that limits star formation," observes Jeff Hester, who, along with fellow Arizona State University colleague Paul Scowen, took this picture. The development of stars that were still being hatched was arrested when their cocoons were shattered by ultraviolet light from hot, massive stars. Like premature babies, these smaller stars found themselves unexpectedly exposed to the universe, their birth process terminated before they were fully grown. This is the first clue as to how small stars may arise from a rich environment of dust and gas from which they could have drawn a lot more mass.

JEFF HESTER AND PAUL SCOWEN/ASU/NASA

ment over the initial 90 percent rejection rate, before the Hubble was running at peak efficiency.

Staff at the STScI do a quick screen of the proposals to make sure they are technically feasible. Then they're sent to one of a dozen or so panels that together make up the Telescope Allocation Committee. The TAC, as it's called, is a jury of peers, astronomers drawn from various universities and educational institutions who sit on the committee for a year. In the fierce intellectual competition of professional science, the TAC's job is to find fault or chinks in the logic—subtle reasons why you and your idea should be sent packing to some smaller, less rare telescope. At this level, almost every proposal is a good one, says Mike Shara of the STScI's Science Program Selection Office. "There are no loose cannons."

Often it's not a matter of what you want to look at but how. Jupiter and the Orion Nebula, after all, have been pretty well scrutinized. But if you suggest using *this* instrument with *that* filter tuned to a certain wavelength—an elegant way to squeeze an extra bit of science from the same tired target—the TAC might smile on your proposal. If not, well, tough luck. Try again next year. There is no appeal.

So far, more than 4,000 observers have won time on the Hubble, and with that time they have produced data of scientific import and great beauty. Often the two go hand in hand. Pat Harrington of the University of Maryland thinks his image of the Cat's Eye Nebula (below) "is beautiful for the same reason it is interesting, which is all the symmetry in it." When Harrington first saw the picture, the aesthete in him was not unmoved. "It was clearly the best image of a planetary nebula I had ever seen," he says. "I remember saying we had to stop and get some champagne, because this was a spectacular image."

Jeff Hester of Arizona State University, who took another of the Hubble's most breathtaking pictures—a stellar nursery in the Eagle Nebula (opposite)—admits to being surprised at the "totally off-scale" public reaction to the photograph. He recognizes its aesthetic appeal, but he thinks the scientific yield from Hubble images of the Crab Nebula (p. 38) will ultimately be richer. "The joke about the Crab Nebula is that any instrument that can be point-

An average star like the sun will end its life by swelling up and casting off its outer layers, leaving behind a huge cloud of expanding gas known as a planetary nebula. The Cat's Eye is a planetary nebula located 3,000 light-years away, in the constellation Draco. It is also a source of X-rays, which is why it was chosen for a look by Hubble. The intricate patterns of the Cat's Eye serve as a fossilized record of a dying star and its probable companion star, seen here as a bright white object at the center (the stars are too close to be distinguished from each other). Blowing outward from the dying star is an elongated bubble of dense, glowing gas, which is enveloped by two larger lobes of gas cast off at an earlier stage. Encircling the lobes is a bright, clumpy ring of gas.

The Cat's Eye structure seems to indicate that the companion star may be feeding upon the dying star by pulling away its remaining gas, yielding a fast-moving accretion disk around the companion and twin jets of high-speed gas blasting everything in their path. The jets' forcefulness no doubt produced the two greenish, highly compressed bands of gas visible at the outer edges of each lobe. The Cat's Eye nebula is an artificial-color composite of three images recorded at different wavelengths.

J.P. HARRINGTON AND K.J. BORKOWSKI/STScI/NASA

In 1054 A.D. sky watchers in China and the deserts of the southwest United States saw a new star appear in the constellation Taurus. Months later it faded from view. Now the Hubble has produced a detailed image of the Crab Nebula, the swirling filaments of gas remaining from the supernova explosion that tore the star apart. The filamentary structure marks an unstable region at the expanding interface between cooler gas on the outside, ejected toward the end of the star's life, and a magnetized cloud of energetic electrons expelled by the pulsar at the heart of the Crab catching up to and interacting with the previously ejected shell. This false-color picture shows light emitted by cool oxygen atoms (red), hot oxygen (green), and sulfur (blue).

JEFF HESTER/STScI/NASA (2)

ed at it has been," he says. Even so, the Hubble's instruments revealed an undiscovered knot of material very near the Crab's central pulsar.

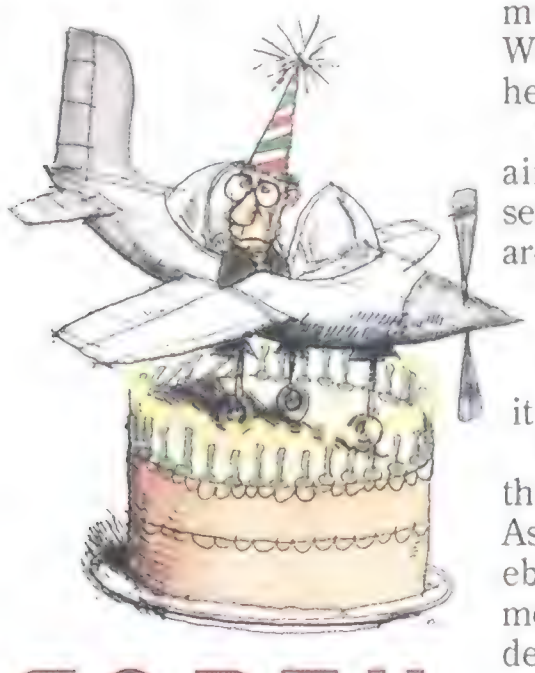
Because Hester helped design the Hubble's Wide Field and Planetary Camera 2 (WFPC 2), which took the Crab Nebula picture, Hester is a GTO, or guaranteed-time observer. Sounds enviable, but the 200 hours awarded to him and the rest of the WFPC team ends up being "not all that much, frankly"—not when they all have ideas for more studies than they can possibly execute.

Hester had recently finished grad school in the 1980s when he accepted a job working on Hubble instrumentation, and he had some reservations. "I was afraid that I was probably walking away from science," he says. The Hubble was being built primarily for cosmology—to view the faintest, most remote objects—not for his own specialty, nebulae. But it turns out that the Hubble can generate real breakthrough knowledge in Hester's field as well. Now, with a string of bona fide hits to his credit, Hester says: "I'm proud of what we've accomplished," not only for science but for public awareness of astronomy. "It makes you feel good," he says, "to get calls from people who are not astronomers who say 'You know, I don't understand the science, but I'm glad we've got a picture of that.' "

About 15,000 years ago, when Earth was in the grips of the last ice age, a supernova at a distance of 2,600 light-years exploded in the constellation Cygnus, creating a rapidly expanding blast wave. Today its remnants, known as the Cygnus Loop, are spread over 100 light-years of interstellar space. In this image, a corner of the Cygnus Loop, moving from left to right, runs into a clump of denser interstellar gas to the lower right. The resulting collision sends a shock wave through the clump, causing its gases to glow: Green marks hydrogen atoms; red, sulfur; and blue, hot oxygen.

by Stephan Wilkinson

Illustrations by Richard Thompson



FORTY YEARS OF FALCOS

A birthday bash at Oshkosh celebrates the anniversary of a time-honored design.

It was a quiet Thursday morning, and the air traffic controller working my flight from upstate New York to Oshkosh, Wisconsin, was in a chatty mood. "Experimental Seven Sierra Whiskey, what kind of airplane is that?" he asked.

"It's a Falco," I told him. "An Italian airplane. Real fast, aerobatic, two seats...built it in my barn. Design's been around awhile; they used to make 'em in Italy. In fact, this year is the 40th anniversary of the design."

"Forty years? Why do they still call it experimental?" he asked.

Good point, for I was on my way to the 1995 annual Experimental Aircraft Association Oshkosh fly-in to help celebrate the 40th birthday of one of the most proven yet rare homebuilt-aircraft designs in the sky. As a bonus, its legendary designer was en route from Italy to blow out the candles.

In June 1955, the first Falco, a small, classically proportioned wooden lightplane that looks more like a shrunken fighter than a private pilot's puddle jumper, was dragged atop a wagon to the Linate Airport, outside Milan, by a team of horses. The airplane had been designed and built at a shop in the city by a little-known aeronautical engineer named Stelio Frati and his crew of craftsmen. Frati had designed the airplane, to be made of native poplar in simple Italian woodworking shops, to live on long after his more modern metal designs—military trainers, commuter-liners, turboprops, jets—had had their day in the sun. When the test pilot for the Falco's first flight landed, he climbed out of the prototype and said, "*Ingenere* Frati, congratulations, but you will never do that again. The handling is perfect. If this is the only airplane you ever design, you will live a happy man." Today Frati, 76, a small, seemingly humorless man with a raspy voice, is known for much more; in fact, he is considered by many to be the world's finest designer of fast, elegant, and efficient light aircraft.

The Falco was Frati's eighth design. Five of them had progressed far enough to actually fly—this in a country still stumbling through the rubble of World War II, a country where horses were easier to find than trucks. One of those airplanes was powered by a tiny 330-pound-thrust jet and first utilized what were eventually to become the Falco's wings and tail. Another was a very light four-passenger twin with 85-horsepower engines, and a third was the Rondone, an 85-hp hummingbird that presaged the Falco phenomenon by setting a number of speed records in the early 1950s.

Still, he must have been at least a bit nervous when the Falco first took off. "Nervous? You do not know Engineer Frati," said his business partner and interpreter, Carla Bielli, a forthright, reddish-blonde woman who came to Oshkosh with Frati to join in the birth-

day celebration. She invariably refers to her boss by his title—*Ingenere*—an honorable one in a country that created the Ferrari, the Stradivarius, and the daydreams of Leonardo da Vinci.

"When all of his aircraft first fly, Engineer Frati is very sure of them," Bielli said in a thick Milanese accent. "Only once was he nervous: flying in the Squalus, his new jet. He was worried that his ejection seat might go off."

Actually, there was one event during the Falco's development, decades before the Squalus' introduction, that indeed did scare Frati. During a load test in which strain was applied to the wing's main spar and slowly increased, a government aviation inspector with a warped sense of humor loudly snapped a stick of wood behind Frati's back. "Engineer Frati, he jumped like *this*," Bielli demonstrated. Frati did not smile.

Bielli translated while Frati—who lives in the heart of northern Italy, where God goes to eat when he's sick of French food—suffered through a banquet at a Wisconsin restaurant known to a decade's worth of Falco enthusiasts as the Roadkill Inn. "What means rudkill?" Bielli asked, and someone explained that it is what a waitress answered at an earlier Falco dinner when asked the source of the mystery meat being served. On this night, however, dinner was slabs of prime rib the size of hubcaps. "*Questo?*" Frati asked, poking at his mat of bloody beef. Bielli said, in Italian, "It is a hideous, enormous piece of a cow. Be polite and eat it."

The room was a babble of builders comparing notes and gauging their progress against one another—"Got the tail section done"..."Starting the ailerons"..."Been working for eight years now"—while those of us lucky enough to be finished with construction were lying about the airspeeds we had achieved. One builder introduced

himself: "Hi, I'm Dan and I'm a Falcoholic." He'll go far in this group of overachieving compulsives.

Yet at that huge convention of do-it-yourself airplanes our birthday party was a bit of a non-event, for the emphasis among the homebuilts at Oshkosh was on the newest, the most novel, the most shocking. There were airplanes on display made of fiberglass, of carbon fiber, of styrofoam. Airplanes with wings that folded, with wings where the tail should be, with no wings at all—lifting bodies, in effect. Even airplanes that were miniatures of airplanes: One builder had created a near-exact flying replica of the Lockheed T-33 T-Bird jet, except that it was only two-thirds the size of the classic Air Force trainer. We were parked among hundreds of wonderful, imaginative, plucky homemade airplanes, designs that ranged from arrogantly futuristic to projects that looked like leftover plumbing from the *Waterworld* set. Yet the Falcos, virtually the oldest design, were still among the sleekest.

We were 18 little Falcos among a total of 718 homebuilts, a grand total of 2,719 if you included restorations, warbirds, ultralights, replicas, and oddities. The fly-in acknowledged our presence by letting us park together, but few among the spectators and other builders knew the real purpose of our gathering. Except, of course, for those who asked the meaning of the T-shirts we were wearing, which said "I came to Oshkosh with the sexiest 40-year-old on the planet."

On the sprawling grass parking grounds, my airplane and its 17 siblings sat in a back-to-back double row. They ran the gamut from utilitarian and well used (a category that included my own) to one so compulsively finished that its propeller was pinstriped and decorated to repeat the airframe's swoopy paint job. Even its engine compartment was aglitter with chrome and marshmallow-white polyurethane paint, and the little Lycoming was painted a sparkling metallic powder blue. Its builder, California roofing contractor Dave MacMurray, was miffed when he saw that my otherwise ordinary engine had a special gold-anodized oil filter, but before the day was out, he had bought one. And before the week was out, he and co-builder and wife Barbara had won the Reserve Grand Champion award—second place, essentially—among all the custom-built kitplanes on display.

Frati roamed the sweating, T-shirted, silly-capped, boxer-shorted crowd unrecognized. He is a thin, fragile-looking man with an equine face behind heavily tinted glasses, and he looked like an elderly *capo* who had taken a wrong turn somewhere in downtown Chicago. He was the only man at Oshkosh in severe business clothes, incongruous under a floppy EAA sun hat that someone had insisted he wear. Yet he is the creator of not only the Falco but the much-sought ex-military aerobat called the SIAI-Marchetti SF.260, and his two newest projects, the General Avia F.22 Pinguino and the Sprint trainer and sportplane, were being exhibited in the United States for the first time.

Frati is a gracious man. At one point he was guided to a homely and inept pusher-propeller machine, one of the few products of a failed attempt to market a four-place kitplane with the engine in back and the passengers in front in a great Plexiglas egg. "Good visibility," he said.

To this day Frati remains baffled by the ability of ordinary do-it-yourselfers to craft an airplane that he had intended solely for factory manufacture. It was the dream of a persuasive, well-off Richmond, Virginia pilot, Alfred Scott, that a roll-your-own version of the Falco should come to pass. Scott, fortunately, was too naive to know better.

"When Mr. Scott first proposed to Engineer Frati that he should sell copies of the plans, Frati said no no no," Carla Bielli recalled. "I told Frati 'You don't know the Americans. They can do *anything*.' " Bielli, fortunately, is an Americophile. "You see in small towns when you come to America millions of people living far from cities, taking care of themselves. Nothing is impossible in the United States. People in the United States, if they have to do something, they do it. When they decided they wanted to go to the moon, they went six times. It is so simple.

"I work with Engineer Frati for 25 years, and in this time we build 10 different prototypes," Bielli continues. "But I never saw that somebody could build this beautiful Falco alone. We are 20 persons in the shop. Somebody ordered materials, some other did drawings, Engineer Frati did design...but now I see how to build aircraft."

Not all Falco builders are Americans. Marcelo Bellodi was one of the 18 who had brought their airplanes to Oshkosh for the birthday party. It was a 33-hour trip from Jaboticabal, Brazil, to Oshkosh behind a lone 180-horsepower Lycoming engine—a trip across 450 unbroken miles of Amazon forest, through an intertropical convergence zone that is usually wall-to-wall thunderstorms, with landings to refuel at Guyana airports amid suspicious policemen and soldiers, then island-hopping the Caribbean to Florida.

Bellodi, young and charming, was a former flight-test engineer for the Brazilian commuterliner manufacturer Embraer, though today he works on his family's ethanol-producing sugar plantations. The farthest he had flown his airplane before coming to Oshkosh was 400 miles, to one of those farms. "A lot of people ask me about the trip from Brazil," he said, "and I answer by telling them how beautiful it was. But more beautiful than that is to be here with all the other Falco builders, who are now part of my family."

Cecil Rives, a Houston petroleum geologist left with plenty of time on his hands after the collapse of the Texas oil boom, finished his Falco in October 1993 and admitted, "I'm a low-time pilot—300 hours—so I was apprehensive about flying a Falco. But my fears were unfounded. Building it, I learned an awful lot about airplanes. But more important, I learned a lot about myself." For others, the building process takes a distant back seat to the flying. "After I finished my Falco and started flying it, I began to resent the time that I'd spent building it," photographer Jonas Dovydenas griped.

When the Falco first went on the market in Italy, it inevitably gained a reputation as "a hot ship"—so fast and delicate in its handling that it would be too much of a handful for mere mortals. Frati, until then a non-pilot, decided to take flight instruction and get his pilot's license in a Falco, thereby proving that if he could fly it, so could anybody. He succeeded, though on one of his very first solo landings, he misjudged his height above the runway and hit the ground with an 8-G impact. The airplane had to be completely inspected before it could fly again. (Of course, the only person in all Italy competent to perform such an inspection was the very student pilot who had mistreated the airplane in the first place.) If nothing else, Frati proved that the Falco was a sturdy bird.

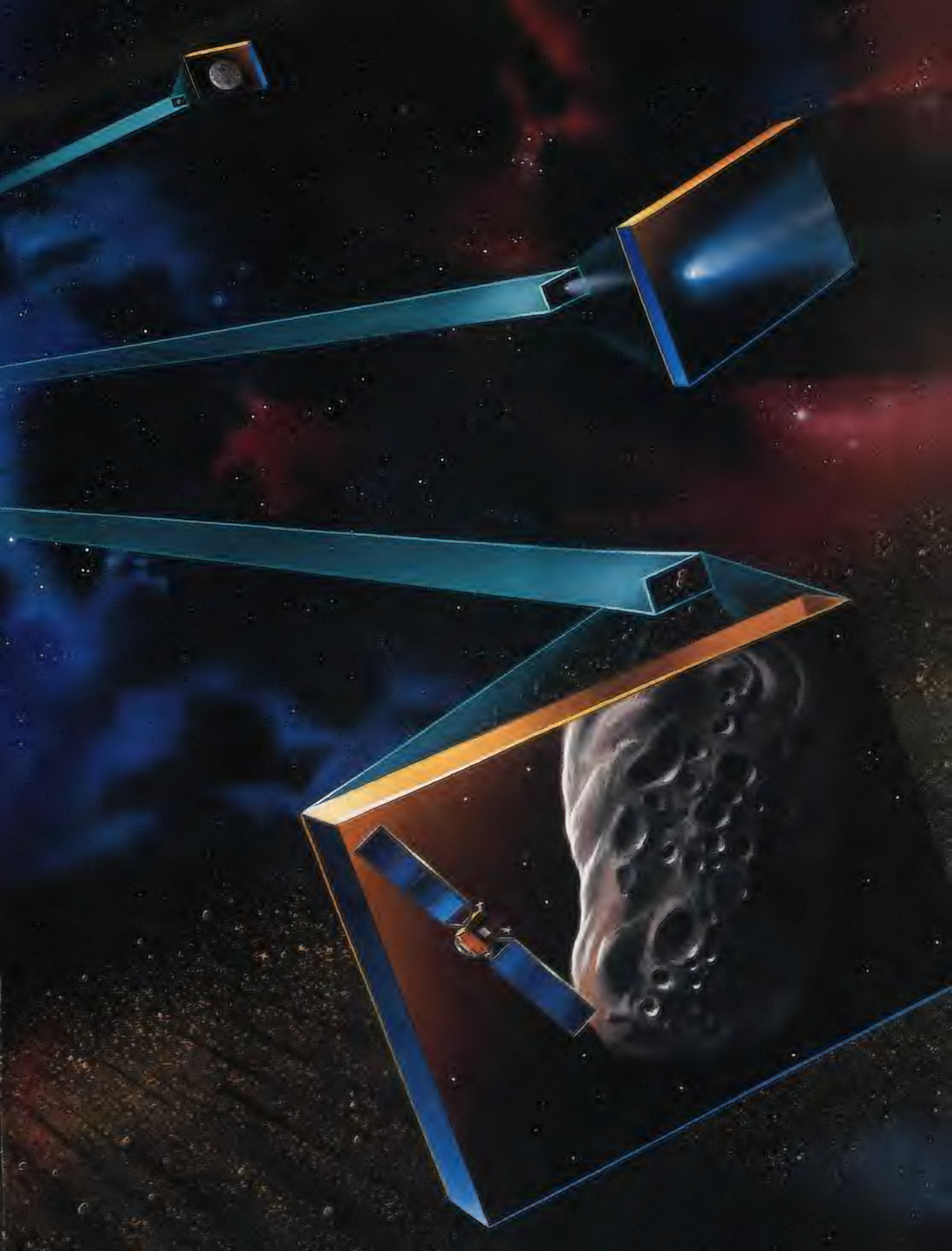
For many airplane homebuilders—and certainly not just those who build Falcos—the experience of creating a machine that actually flies, of crafting from wood or aluminum or plastic composites a device that invisibly, magically casts off earthly constraints, is a powerful, almost mystic passage. "I've built my Falco, and I'm flying it, yet I'm still involved in the experience. And it's not going to end," mused Jerry Walker, who started construction nearly 15 years ago. "I have a difficult time explaining it to myself. I'm in the air, I'm flying, and I'm in this *thing* that I built with my own hands," he marveled. "I never built anything before."

THE NEW MILLENNIUM

Why an ambitious NASA program to develop technology for exploring space is fighting for turf here on Earth.

by William E. Burrows

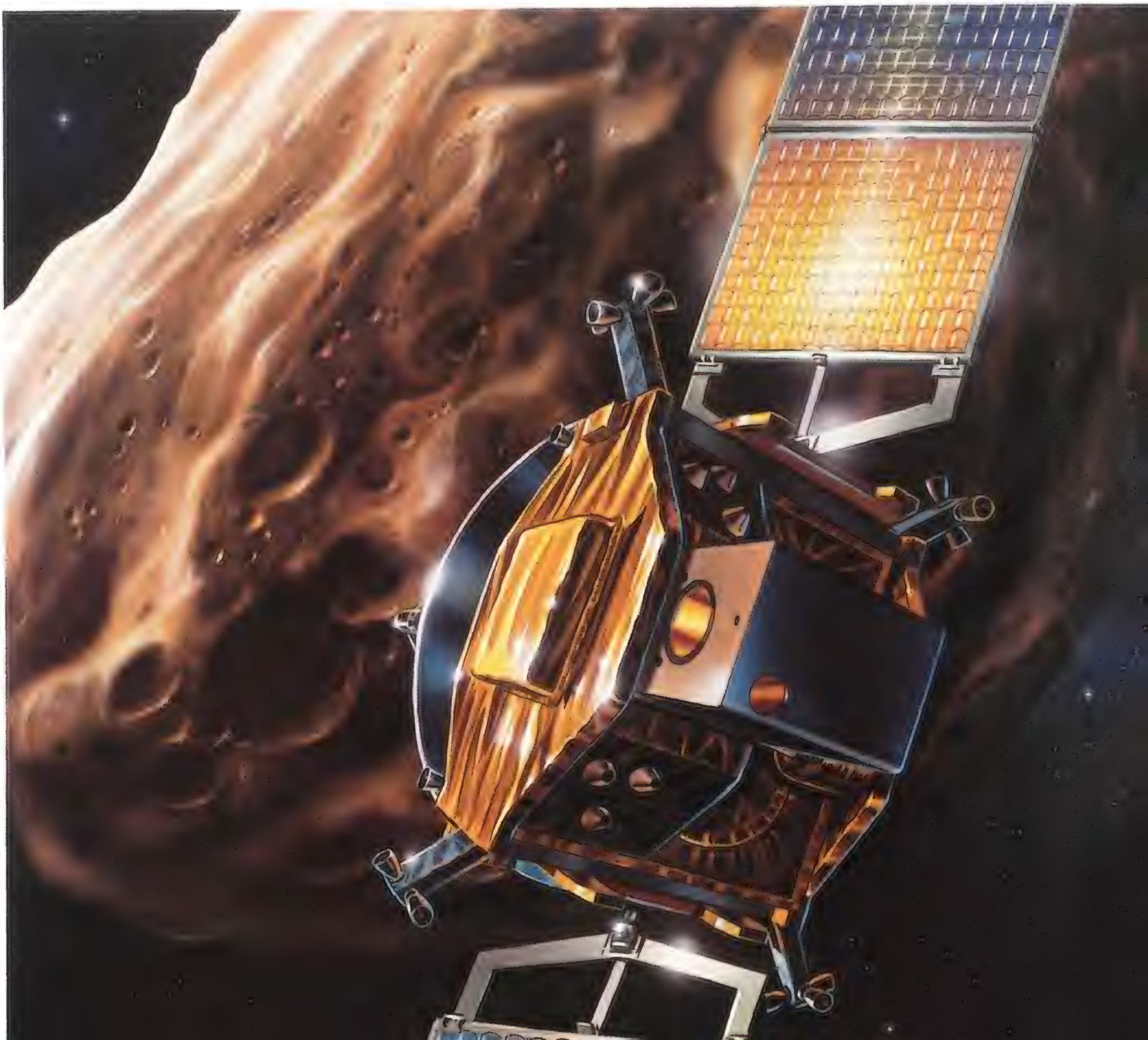
Paintings by Paul DiMare



In 1986, as Voyager 2 was streaking past Uranus during its "Grand Tour" of the solar system and as Magellan, Galileo, and Ulysses were being readied for their own historic encounters with Venus, Jupiter, and the sun, theoretical physicist Freeman Dyson peered into the future and saw a tiny successor to those ponderous explorers. Dyson envisioned creating a spacecraft weighing just over two pounds, which he whimsically called an Astrochicken. Using its own advanced intelligence, this miniature craft would maneuver around the solar system and beyond, landing where it pleased, all the while describing to the humans back home what it discovered.

The path to the future is littered with broken crystal balls, and no one can predict whether anything like Dyson's Astrochicken will ever actually range freely through the solar system. However, his dream seems to be coming true in at least one respect: Much smaller, smarter, and more versatile spacecraft are being developed to succeed those of the golden age of space exploration.

The driving force behind the next generation of spacecraft is not so much technology as a severely shrunken post-cold war space budget. NASA's space science funding request for fiscal year 1997 is $1.85 billion, down from $2 billion this year, and further cuts are possible. The prospect of whole institutions being starved out of existence has turned the competition for programs quietly ferocious. Nowhere is it more so than between two groups fielding competing bantam-weight spacecraft. Clementine, weighing in at a little over 500 pounds, is backed by a group that includes the Department of Energy's Lawrence Livermore National Laboratory, the Department of Defense, and the Air Force's Phillips Laboratory in New Mexico. New Millennium, which tips the scale at about 220 pounds, is managed by NASA and its Jet Propulsion Laboratory in Pasadena.



Clementine's roots go back to the Strategic Defense Initiative—the "Star Wars" anti-ballistic missile system—which was intensively researched during the 1980s. Realizing that large satellites designed to knock out enemy warheads would themselves be inviting targets, SDI engineers set to work on a program called Brilliant Pebbles. In theory, the program's thousands of tiny spacecraft would spot enemy missiles emerging from their silos and then attack them on their own initiative. To work, Brilliant Pebbles would have required major breakthroughs in miniaturization and artificial intelligence.

The end of the cold war and the election of President Bill Clinton technically ended SDI. It also threatened to close the Lawrence Livermore National Laboratory. The sprawling facility east of San Francisco had been run by the Department of Energy primarily as a nuclear bomb design center, with Star Wars research conducted as a kind of diversification measure. With the collapse of the Soviet Union, however, neither undertaking was important enough to justify keeping the laboratory open. Threatened with his lab's extinction, Lawrence Livermore scientist Lowell Wood began searching for projects to keep funding alive. (One of them, a short-lived proposal for an inflatable spacecraft, poached on JPL's turf and probably helped initiate an ongoing battle between the two institutions.) Such were the forces that gave birth to Clementine, a missile defense test craft and a scientific data collector rolled into one lightweight package. It was built by the Naval Research Laboratory and funded by the Ballistic Missile Defense Organization, a scaled-back successor to SDI. Prohibited by treaty from practicing on real missiles, the Department of Defense devised Clementine to see whether an inexpensive spacecraft using miniature sensors and other hardware could spot, track, and image a cold target: an asteroid named Geographos. And in order to see whether Clementine's sensors would keep working in space for a relatively long time, it was also decided to have it image nearly all of the moon in fine detail. The program was started in early 1992 by only 55 people with a bare-bones budget of $80 million.

Program manager E. Kane Casani (above) envisions a new generation of explorers that would use New Millennium's technology to create a "virtual presence" throughout the solar system (preceding pages).

DS1 flight leader David H. Lehman calls his asteroid flyby mission "high risk," but says even a failure would provide valuable information to New Millennium scientists. The mission is scheduled for launch in 1998.

Using its experience with Brilliant Pebbles and with actual test spacecraft called LACE and MSTI (Low-power Atmospheric Compensation Experiment and Miniature Sensor Technology Integration), Livermore built Clementine's sensors and designed the experiments that would use them. This meant that the new spacecraft carried a number of missile defense sensors, including a laser-ranging experiment and four lightweight cameras, one of which was a high-resolution imager. The imaging system was so good, according to mission scientist Eugene Shoemaker, that even rock types were mapped.

NASA also had a hand in Clementine, with the Goddard Space Flight Center in Greenbelt, Maryland, helping to design the lunar mission, JPL assisting with the planning of the asteroid encounter, and the Deep Space Network's massive antennas tracking the spacecraft and providing communication links. JPL engineers, including one named E. Kane Casani, also worked on the first of the MSTI satellites.

A software error in 1994 eventually sent Clementine into an uncontrollable

spin and prevented it from reaching Geographos, but before that it became the first U.S. spacecraft to image the moon since the Apollo 17 mission in 1972. During its 76 days in lunar orbit, the spacecraft yielded a splendid scientific return, including nearly two million images of the lunar surface and radar data that suggested the presence of water ice deposits.

With Clementine, the Pentagon had demonstrated that effective space missions could be conducted on a shoestring, compared to the cost of NASA missions. (Though Clementine did avoid paying the substantial cost of developing its sensors by utilizing SDI and BMDO research that had already been funded by tax dollars.) Unlike the space agency's huge mission control complexes, for example, Clementine operations were run by a handful of people in an abandoned armory in Alexandria, Virginia. The control room was small, dark, modestly equipped, and named "the Bat Cave" after one of its original occupants, which had been dispatched with a broom. In 1998 a second Clementine mission will study three Earth-crossing asteroids.

But Clementine's very triumph worked against it in ways that shed light on the politics underlying the space program. The spacecraft's supporters in the Pentagon believe that the Clinton administration dislikes Clementine because it represents the ghost of Star Wars, which was President Reagan's pet program, and therefore prefers a program to rival it. "They're killing off all work done under the SDI rubric," says one scientist familiar with Clementine. "Americans who worked on national defense are being blackballed because of the SDI effort."

More insidiously, its low cost and the fact that it went from conception to flight in only 22 months denied it support from an aerospace industry that still prefers multimillion-dollar, decade-long programs. And it undoubtedly embarrassed Daniel S. Goldin. The NASA administrator had been vice president of TRW's Space & Technology Group when the firm "put a bloody fortune into Brilliant Pebbles," as Goldin himself has said. Now his former cohorts in the Pentagon were moving aggressively onto NASA's turf, and doing so

NAVAL RESEARCH LABORATORY

with startling success. The spunky little spacecraft helped convince Goldin that his agency, already being pummeled in Congress for excessive spending and inefficiency, had to fundamentally change its ways.

Goldin had already been moving in that direction. More than a year before Clementine's launch he had issued his famous "faster, better, cheaper" manifesto. In February 1994, roughly coinciding with Clementine's arrival at the moon, Goldin started a $108 million Small Spacecraft Technology Program to develop Lewis and Clark, two Earth-monitoring satellites named after American explorers William Clark and Meriwether Lewis. In addition, NASA launched a Discovery Program for various inexpensive exploratory missions to Mercury, Venus, Mars, and an asteroid. New Millennium was conceived in September of the same year.

Unlike the other lightweight explorers, New Millennium is not a spacecraft. It is a concept. Those who work in the program say that their objective is the "flight validation" of new technology. The plan is to build six technology-demonstrating spacecraft over the first five-year period—three for solar system exploration and three for near-Earth missions—which can think for themselves and require little handling from the ground. Pure science is not what New Millennium is about. Rather, it is to provide breakthrough technology that will form the basis for robotic space missions in the next century. E. Kane Casani, now New Millennium's program manager, and others envision scores of $150 million solar system exploratory missions that would use New Millennium's breakthroughs. Some would disgorge tiny rovers to study Mars or moons such as Jupiter's Europa. Others would send penetrators into the Martian crust for seismological investigation and water sampling. Still others would dot the Red Planet's surface with miniature weather stations or retrieve samples from comets. Casani says that there could eventually be a New Millennium launch every month (the remark will have a familiar ring to anyone who remembers the overly optimistic launch rates predicted for the space shuttle).

For such grandiose plans, funding is

In 1994 Clementine returned 1.8 million detailed images of the moon's surface—and helped spur NASA's drive to create smaller, cheaper spacecraft. The Clementine image of Rydberg crater (opposite) was taken from an altitude of just over 300 miles.

relatively modest. NASA received $10.5 million for New Millennium in 1995. Congress appropriated $30 million for 1995-1996 without objection and NASA will ask for another $21.5 million for 1997. JPL is to run three of the technology demonstrators, each dedicated to deep-space operations, while the Goddard Space Flight Center will adapt three for Earth-orbiting missions.

The heart of New Millennium comes from JPL's Microdevices Laboratory, set up in the late 1980s to study miniaturized space components. Voyager's total imaging system weighed approximately 144 pounds. On New Millennium solar system explorers, the figure would drop to 11 pounds. Future imaging systems could shrink to mere ounces. The Planetary Integrated Camera-Spectrometer would be made of tough but lightweight silicon carbide, a non-metal so strong and heat-resistant that it is used to line ovens. It would use miniaturized imaging technology, and the imaging systems themselves would be self-sequencing, capturing what is required without being directed by the people they left behind.

Propulsion for New Millennium solar system explorers will most likely come from so-called ion, or electric, engines. In an ion propulsion engine, the atoms of a gas propellant such as xenon are stripped of their electrons, creating a positively charged plasma. Thrust is provided by an electric field, which accelerates the particles out of the spacecraft. Initial velocities of the vehicle would be turtle-like, but in the vacuum of space they would slowly increase to more than 200,000 miles per hour. The electric power would come from solar arrays covered with the equivalent of magnifying glasses to greatly increase the energy they absorb from the sun.

The system's brains are being given enough artificial intelligence so the craft can guide themselves to their destinations, collect what is required, and respond to trouble without help from the ground. "A lot of us have gotten really excited by the idea of these autonomous spacecraft—spacecraft that basically do everything on their own," says Ellen R. Stofan, New Millennium's in-house program scientist. "You have a really smart spacecraft that can figure out what to do. It can make its own trajectory corrections and maneuvers and doesn't have to send data back and forth to the ground; it does that all onboard." This, she says, should bring down costs and greatly increase the launch rate. The eventual goal is the creation of a "virtual presence" in space, giving people back on Earth unprecedented amounts of data. "From a scientific standpoint," Stofan adds, "it blows your mind."

The task of developing and integrating highly complex technology in uncharted organizational waters has already lent

a certain internal cachet, an aura of technological derring-do, to New Millennium. Its 65 full-time scientists and engineers at JPL constantly refer to their program as a "high-risk" operation. The references to danger seem to provide them with psychic insulation against catastrophic failure, as if something quite wonderful could grow even out of the ashes of disaster.

Says David H. Lehman of the program's artificial intelligence technology, "If we fly it and it doesn't work but we know why it didn't work and the mission fails, we're a success because we can use that data and say, 'No, we would never do this again.' We are a high-risk mission," he adds proudly, echoing his colleagues. "If we're low risk, we're not doing our job."

Lehman will be among the first to be tested. He is the flight leader for DS1, the inaugural deep-space mission, which is an asteroid-comet flyby scheduled to be launched in 1998. The craft is supposed to fly past an asteroid, not so much to collect data about the speeding rock but to see how the vehicle performs with a rapidly moving target. (The Clementine contingent, naturally, thinks DS1 is reinventing the wheel.)

The second deep-space mission will head to Mars. Its flight team leader is Sarah Gavit, who holds two degrees in aeronautical engineering from MIT, has time on both the Magellan mission and the Cassini flight scheduled to go to Saturn next year, and is one of 14 women among New Millennium's team of scientists, engineers, and managers. Gavit's DS2 mission will punch a pair of four-inch penetrators—smart darts—into the Martian surface, where they will collect data on subsurface chemistry. Both penetrators, nestled within aeroshells designed to protect them from the Martian atmosphere during entry, are supposed to be released and come in "like badminton birdies" while their carrier is boring in for its own landing. The darts are designed to plow one to six feet deep into Mars but leave their tails, which include antennas, batteries, and meteorological sensors, on the surface to relay data to an orbiting mothership—a previously launched Mars Global Surveyor—for transmission to Earth. Gavit would eventually like to salt Mars with networks of up to 20 penetrators and/or landers that will search for signs of life, listen for Marsquakes, and take simultaneous weather readings from many locations.

The probes are scheduled to hitch a ride on the '98 Mars Surveyor Lander (actually scheduled to launch in 1999). Piggybacking to Mars, though, is not like thumbing a ride to Cleveland. The agreement required negotiations with JPL's Mars Exploration Program Office, which is responsible for the 1998 Mars Surveyor Lander mission. Donna L. Shirley, who manages the Mars Exploration Program, had her own concerns. A UCLA scientist had won a stiff competition to get his experiments on the lander, and although Shirley was sympathetic to New Millennium, her orders were to give the UCLA researcher first priority.

The launch vehicle originally scheduled for the Mars Surveyor Lander mission was a Delta 7325, equipped with three solid rocket motors and capable of launching about 1,250 pounds into orbit. Although the penetrators weigh just 18 pounds combined, DS2 was granted a place on the mission only if New Millennium agreed to provide an additional booster at a cost of $1.6 million. The fourth rocket motor will add an another 155 pounds to the vehicle's launch capability.

Before the new technology can fly, however, New Millennium has to overcome an array of political challenges, including rivalry with other institutions, disgruntled employees who feel either left out of decision making or who don't like the decisions, young scientists and engineers who are long on exuberance but short on successful mission experience, and an organizational structure

Both Clementine and New Millennium have roots in the Strategic Defense Initiative's "Brilliant Pebbles" program, which would have used tiny satellites to spot and destroy enemy missiles on their own initiative.

that is both fragile and complicated.

Traditionally, projects, which involve only the spacecraft and its operation, have been run by field centers such as JPL and Goddard, while programs, which include selecting and contracting for the launch vehicle, coordinating work with other centers, and related support activities, have mostly been run by headquarters. New Millennium and two other JPL operations—Cassini and the decade-long Mars Surveyor Program—are the first programs in three decades to be run by JPL itself. The idea is to cut costs even further and improve integration by keeping much of the operation in-house.

But that attempt at simplicity stands in contrast to an otherwise complex organization. New Millennium has six groups called Integrated Product Development Teams, composed of representatives from NASA, other government agencies, industry, and academia, to decide which "revolutionary" or "breakthrough" technologies need to be validated for the science requirements. Inspired by corporate strategy in which companies determine product niches that need to be filled and then set out to fill them, each IPDT will focus on a specific area, such as autonomous spacecraft systems or microelectronic devices. All six IPDTs are supposed to work with the six flight validation teams. The validation flight proposals themselves were selected by yet another team, this one studying the missions' architecture. And the IPDTs receive their direction from a Science Working Group, which consists of some 20 scientists from government and the private sector who are supposed to give the IPDTs their wish lists of what ought to be investigated.

To further complicate matters, it was decided at New Millennium's birth that industry would also participate. While there are to be no prime contractors, according to Kane Casani, plans call for long-term deals to be struck with a cadre of specialized firms so that a permanent, stable infrastructure can be established. The point is to get industry involved early enough so that it comes up with its own ideas in conjunction with the IPDTs. Integrating the program with the companies will in turn be the responsibility of a New Millennium Council, whose precise role remains vague.

Barbara A. Wilson, chief of the program's technology and the former manager of JPL's Microdevices Laboratory, says that firms that expected to be told what to produce were initially confused when required to come up with their own ways of meeting technological requirements.

For all the talk about streamlining the process (New Millennium is described as "relatively simple and straightforward" in one overview of the program), its growing infrastructure is reminiscent of the labyrinthine system it is supposed to replace (a point the Clementine team members make with relish). Wilson cheerfully acknowledges the challenge. "The demands to try to bring the rest of the world into the program are overwhelming," she says.

Even at JPL itself some people are resentful because they have not been invited to join. "People didn't get involved initially," says Suzanne Smrekar, a flight scientist, "and that created estrangement." One individual complains that the program's "fast track" approach, which provides scant information to "outsiders," courts disaster in software development, particularly because of the speed with which decisions are made. The program's managers acknowledge the risk but counter that speed is an integral part of the process because it keeps costs down. And although Casani and his cohorts take pains to explain that theirs is a technology demonstration program with science deliberately relegated to the back seat, some scientists have complained that the emphasis on technology has shut them out of the program.

But the squabbling in Pasadena, typical for a new program, pales in comparison to the clashes in Washington between NASA and Clementine's supporters. Both sides act like feuding cousins forced to cooperate on some fundamental issues while locked in a battle for control of the family fortune.

The dwindling money for space has forced NASA and the Air Force, long uneasy, distrustful, and even distant relatives, into unprecedented cooperation on technologies they both need, such as advances in multispectral imaging and solar panels. Wilson, for example, was once a member of the Air Force's Scientific Advisory Board and in 1995 helped it produce a report that mapped out an Air Force strategy for controlling space well into the next century. Not surprisingly, the report calls for the Air Force's spacecraft to shrink and to be cheap, mass-produced, organized for a single function, networked with other spacecraft, and highly autonomous. In order to do that, the document explains, it will be necessary to embrace technologies that come from many places, including the civilian sector.

Wilson says that the Microdevices Laboratory has been the primary facility for the BMDO's own advanced micro-technology for the last five years. But it's a two-way relationship. The Phillips Laboratory in Albuquerque, New Mexico, which is the Air Force's premier space sciences center, is working so closely with New Millennium that its representatives sit on almost all of the program's development teams and help plan the architecture for the validation flights. Wilson says that the two organizations are "extremely closely linked." There's "a lot of ad hoc interaction going on," she adds, because of "financial reality. You just can't do it on your own. New Millennium can't have technologies ready to fly if we're only going to be working off NASA money." The Air Force and the BMDO, she notes, have probably out-invested NASA in important space technology "by an order of magnitude"—a factor of 10.

The economic imperative is not only shrinking spacecraft and their support systems but drawing the "black" military and intelligence programs and the "white" civilian ones into an ever-tighter relationship that emphasizes shared technologies and even missions. It is no coincidence that Spectrum Astro, the Arizona firm building MSTI, is slated to make DS1 and will contribute key parts to the Discovery Lunar Prospector mission and Mars Surveyor.

Lyn Pleasance, who managed Livermore's part of Clementine, says he and the rest of the team would like to work on New Millennium but have not been invited to do so. "We all take pride in the fact that we were out there, leading the way," he says, adding that "if New Millennium follows through on its promise, then in some sense part of the job that we took on for the BMDO, which was the transfer of technology into the community, will have succeeded." It is a generous response from a scientist who believes New Millennium owes a great debt to Clementine.

Gregg Vane, who manages JPL's advanced planetary instruments office, does credit Clementine with playing "a very positive role" in the design of New Millennium's imaging system. "They put billions and billions of dollars into detector development," he says of the SDI-BMDO effort. The problem, Vane adds, is that the Star Wars sensors were designed to see bright objects against a dark background. That's important for spotting missile heat plumes, he explains, but it's not a good fit as far as science is concerned.

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New Millennium's DS2 mission will release two small probes (opposite), which will penetrate the surface of Mars and relay data on subsurface chemistry to an orbiting mothership. DS2 flight team leader Sarah Gavit (above) hopes to see entire networks of penetrators on the Red Planet one day.

Other members of the Clementine team and their supporters have been less sanguine than Lyn Pleasance. They have launched a series of bitter attacks on New Millennium in Congress and the news media. "While giving lip service to developing its own 'faster, better, cheaper' capability, NASA appears to be pursuing the business as usual approach," Ambassador Henry F. Cooper, a past SDI director, wrote to Representative Robert Walker, chairman of the House Science Committee, in July 1995. "NASA seems to be investing heavily to try, through its Discovery and New Millennium programs, to duplicate a Clementine-like capability in its own bureaucracy, but with several overlookers for every worker," he added.

Such reactions have had an impact in Washington. While Congress' NASA authorization for the 1996 fiscal year praised New Millennium, it also noted that the Pentagon and the Department of Energy had been working on similar technologies since the late 1980s. Accordingly, the bill ordered NASA to "contribute to the Department of Defense's Clementine 2 mission to develop technology for small and miniaturized satellites, including the flight demonstration of several microsatellites. This is not a new-start for NASA," the legislation continued, "but an opportunity to leverage Department of Defense technologies for NASA's New Millennium program."

New Millennium's greatest challenge comes not from the outside, however, but from within. Clementine was run by old hands who used existing technology. New Millennium, on the other hand, must do everything at once and quickly in order to overtake the Pentagon and, in the process, help NASA survive. That means it has to produce breakthrough technology while simultaneously selecting the scientific goals that the unfinished technology is supposed to accomplish.

And it is trying to do that with scientists and engineers who are notably light on real mission experience and who, in the words of one experienced space veteran, "have no idea how punishing point failures are, even when they're labeled technology development." New Millennium's goal is laudable, he says, but its process smacks of dangerous self-deception. "It is a children's crusade," he adds warily.

Furthermore, while a $150 million mission is certainly cheaper than, say, Galileo's $1 billion-plus cost, a dozen a year add up to $1.8 billion. Even allowing for expenses to come down, that is a hefty price tag.

At JPL, New Millennium scientists think it's a good investment. An ebullient Donna Shirley explains, for example, that the first couple of missions back to Mars will cost about $220 million apiece, including the launch, and that those to follow are expected to come in at substantially less. A couple of hundred million, she adds, is what it costs to make a movie. "So for the price of a major motion picture every two years, you, the public, put down ten bucks, like going to a movie, and you get to go to Mars." She claims to be thinking of *Waterworld*. But maybe it's really *Flight of the Astrochickens* that she has in mind.


Antenna
Transmitter
Batteries
Batteries
Data Path
Aeroshell
Soil Analysis
Accelerometers
Batteries
Support Electronics

The Climb to the Top

by Larry Lowe

Photographs by Bill Crump

The windsock at Clarence E. Page Municipal Airport outside Oklahoma City is pointing stiff as a board this afternoon, and the late-May sun is baking Oklahoma in the worst drought of the century. United States Aerobatic Team trainer John Morrissey squints into the sun and wind to watch rookie Diane Hakala practice for the *other* America's Games of 1996, the ones without the massive media campaign and huge corporate sponsorships.

Hakala's rakish Staudacher monoplane makes a run toward Morrissey, pitches up into a vertical climb, draws a line, twirls one and one half times about the now-vertical fuselage, draws another line, coasts to a halt, pivots sideways cleanly about its center of gravity, draws another line, executes a stunningly precise three-quarter outside snap roll, draws another line, and pitches startlingly nose forward to fly away inverted downwind. "Good turnaround. A *handsome* down three-quarter snap," Morrissey notes for the practice videotape. "Don't change a thing."

After a 16-year absence, the World Aerobatic Championships have returned to the United States, and despite the fact these largely unknown Olympics of the pilot's art are overshadowed by the games in Atlanta, the tiny aviation community surrounding the sport couldn't be prouder hosts or more determined to make this the best one yet. With 103 competitors from 25 countries so far scheduled to arrive at this airfield for opening cermonies on August 18, it's the biggest in the 36-year history of the contest.

In world aerobatics competition the term "American" has long meant second rate. Can the 1996 team turn that around?

It may also be the most important contest the U.S. pilots have faced. After decades of cultural myopia and an only brief domination of the sport in the early 1970s, the United States has had to relearn what it takes to win at the world level in competition aerobatics. Since the U.S. team's dismal fourth-place performance at the 1994 World Championships in Hungary, the United States has totally redesigned its approach to the sport and its training process. Now the 10 members of the U.S. team—evenly divided into five-person men's and women's teams—are about to learn how successful their effort has been.

The reasons the United States lost its dominance in the sport have to do with geography, politics, and time. At the first world aerobatic contest, held in Bratislava, Czechoslovakia, in 1960, the United States fielded a team of one: a Texas cropduster and airshow pilot named Frank Price. Price finished 24th out of 29 pilots, but he brought back a wealth of experience. He stayed in close contact with the European competitors, and the newly formed Aerobatic Club of America guided U.S. participation in world-level competition with one goal: sending a team to compete at the world meet. At the time, there was one class of competition flying, known as the Unlimited, and no more than a handful of U.S. pilots capable of flying at the world judging standards of that level.

In 1970, the somewhat misnamed International Aerobatic Club was formed in the United States to foster domestic aerobatics. The idea was to develop a pool of talent that could move up through local contests and increasing levels of difficulty, gaining the skills and experience required to compete in the Unlimited class and, eventually, in the world contest. Building its infrastructure in relative isolation from European influence, the IAC developed a distinctly

Like the nine other members of the U.S. team, pilot Matt Chapman is aiming high at this summer's World Aerobatic Championships.


AEROSHELL
58
LY-CON

ROBERT ARMSTRONG

DEBBY RIHN-HARVEY AND LINDA MEYERS MORRISSEY

DIANE HAKALA

American style based on rather strict interpretation of the rules intended to reduce the subjectivity of judging. That style, enforced by the training given to judges, treated aerobatic flight less as art and more as engineering, with an exacting—if uninspired—form of flying being rewarded with higher grades. In an attempt to level the scoring field, the United States had lost sight of the true nature of the sport, which is closer to ballet or ice skating than, say, a military drill.

In 1982, the IAC took over conducting the Unlimited class, the U.S. nationals, and the team selection, and the fate of a generation of U.S. aerobatic teams was sealed. By now, team members who had worked their way up through the IAC ranks were steeped in a style of flying altogether different from the world standard. So were the judges at the U.S. national contest. Flying to IAC standards forced a certain conservatism. "The Americans fly like they are scared of losing," notes four-time former U.S. team member and international judge Bill McIntyre. "The Europeans fly to win."

For a time, the United States thought it could impose its style on the world community, but the results were less than positive. "Up until recently, our attitude has been 'We're right and they're wrong,' " says U.S. team member Robert Armstrong, a professional pilot. "We've had the isolationist attitude that the rest of the world is going to have to conform to our standards. Well, we're never gonna win that way."

MATT CHAPMAN AND HIS MUDRY CAP 231 EX

The stylistic difference was compounded by a lack of state-of-the-art technology. For a time, the Americans did possess an advantage with their airplanes, particularly the Pitts Special in the early 1970s. In the mid-'80s, the appearance of a new generation of European aerobatic aircraft, such as the Russian Sukhoi, the French CAP 231, and the German Extra 300, erased the American technical advantage.

"In '82 in Spitzerberg, Austria, I remember [Russian world champion] Viktor Smolin walking around measuring every airplane that was there, everything the Americans had," team veteran Linda Meyers Morrissey recalls. "The French were doing the same thing.... They needed to come up with an airplane to beat these Americans. And they did."

The U.S. team fared well enough through the 1980s, but by 1990, they were simply not flying the style of aerobatics the European judges expected to see. In his 1975 book *Aerobatics*, British great Neil Williams wrote, "If the slow roll was the foundation of basic aerobatic flying, then the vertical roll can be said to be the key to world championship flying." Things have changed since then. "Everyone can do vertical rolls," U.S. team member Phil Knight says. "If you can't do a straight line in a vertical roll, you ought not be in Unlimited. That's a given." An electronics engineer turned businessman from Florida, Knight physically resembles everyone's gruff high school P.E. coach but exhibits a gentle demeanor and speaks in a thoughtful, precise manner. As he explains it, the Unlimited is now a game of snap rolls. In a snap roll, the airplane corkscrews through the air as if it had one wing. "The deal is to make them as aggressive as possible, and to keep them aggressive right to the absolute," Knight says. It's telling that European trainers will dismiss a poorly executed snap roll as an "American snap."

But that's not the worst part. For some time now, U.S. pilots have wondered out loud why they were not scoring as well as the other competitors. This led to complaints of poor judging and protests to change the Unknown sequence at a contest, all of which have set the tone of U.S. involvement in the

TEAM MEMBER JOHN LILLBERG FACES THE PRESS

sport as one of looking outward to explain poor performance rather than inward. According to current U.S. national champion Michael Goulian, the world aerobatic community has tended to regard the U.S. fliers as amateurs, as hobbyists, rather than as serious aerobatic pilots. "The U.S. team really wants the entire world to understand how hard they train and how serious they take it," he says.

There's an ice-soaked towel waiting for Diane Hakala back at the hangar. It's just one of the myriad details team manager Boris Baird has arranged for the training session. "I can remember flying missions over North Vietnam," Morrissey recalls; "the thought of that cold towel waiting was enough to get me back home."

Morrissey runs the entire training camp from a two- by three-foot bulletin board in the main office of team headquarters. A daily schedule is posted there, detailing the 10 pilots' practice time slots. Each gets three 20-minute slots daily, spread out over five sessions, with the order of pilots rotating daily. With Morrissey alternating the training with U.S. judge Alan Geringer, the pilots have plenty of time to prepare, fly for 20 minutes (enough for two sequences or a sequence and some individual figure practice), recover from the physical stress, and conduct a detailed debriefing with the trainer in a room equipped with a television and a VCR.

Traditionally, this late-May team practice session is the beginning of the run for the world championships. This year, it's merely the first time the team has worked together. Over the winter the United States Aerobatic Foundation provided funding for pilots to continue individual training. The foundation also provided a list of approved trainers knowledgeable in current world style—including the current world champion, French pilot Xavier de Lapparent, as well as former Soviet team member Sergei Boriak—that U.S. pilots could rely on for one-on-one technique development. Meanwhile, the pilots have been individually working to sharpen their edges before coming to this training camp. Airline pilot and fixed-base operator Debby Rihn-Harvey, for example, rises at 5:30 a.m. to get in a practice flight

The Gender Factor

One odd aspect of the World Aerobatic Championships is the fact that while men and women compete as equals, with the Aresti Cup awarded to the highest placing pilot overall, there are separate sets of flight medals and team trophies for men and women. While U.S. women aerobatic pilots differ as to the present need for the separate distinction, they agree that in the past, there's been good reason for it.

When Mary Gaffaney, the groundbreaker for U.S. women in competition—now 70 and still flight instructing in Florida—was the sole woman on the United States team in 1968 and one of only two in 1972, she believes she detected a subtle discrimination in scoring. In 1972, "just before the last sequence, I was very high [in the standings]—I don't know, second or third or fourth—and one of the judges came to me and he said, 'We've never had anything like this, a *woman* up in this position.' I said, 'Oh, you'll think of something,' and on the next sequence I zipped down [in standing]." Gaffaney went on to become the first American to win the title of Women's World Champion that year, placing fifth overall and winning the women's gold medal on the Freestyle and the Known. She feels that a separate set of awards helps level the scoring field.

Betty Stewart was the first person and only woman to win the gender title of World's Champion twice, with wins in 1980 and '82. She was also the first woman who publicly stated the goal to win overall outright. "Oh, yes," she recalls. "It was also my ambition to be American National Champion, but due to politics at the time, I knew that was never going to happen either." Yet she feels the gender distinction is no longer needed. "I'm not sure if it really ever was," she says. "I think it got derived from all the other Olympic sports at one time where there were separate categories for men and women due to physical limitations. I don't think there is a physical limitation to aerobatics."

Linda Meyers Morrissey is the most experienced pilot on the current U.S. team, having been a member since 1982.

continued on next page

each morning before work.

Armed with the knowledge gained from two extended visits to the Russian aerobatic training camp, Morrissey toured the pilots' home bases in February to evaluate them individually. The results of their efforts are apparent in the quality of the practice flying and the focus of the training. "I'd be comfortable taking three of the pilots and putting them in a contest tomorrow," Morrissey notes. "If they can stay as good as they are, they're gonna do great." The rest are not far behind.

With two and a half months remaining before the competition, most pilots have mastered the Known sequence, a compulsory string of figures published by the contest authority before the contest begins, as well as their Freestyle sequences, which each competitor creates. They'll have the remainder of the summer to polish details such as the presentation of the flight, wind correction, and the figures they might run up against in the Unknown sequence.

The Unknown is the last sequence in the competition and, because it is presented to the pilots no more than 24 hours before their performance, the most challenging. Preparing for a practice Unknown just handed to him, Michael Goulian studies it intently, then consults a small black diary. On each page, he has neatly inscribed a complex Aresti figure that might appear in an Unknown, and below the drawing are detailed notes on the figure's entry airspeed, control inputs, airplane response, and expected results. A half-hour later, Goulian has not only committed the sequence to memory but refreshed his understanding of the precise techniques required to fly it. During his next practice flight, Goulian presents the Unknown against the fierce wind with surprising dexterity.

Team pilot Robert Armstrong is faced with a special challenge. The Pitts S-1-11B that he is flying is a factory prototype, and the design is still being fine-tuned. A pair of unpainted wing root fairings have shown up on the airplane in an attempt to smooth the airflow, and there are plans to move the battery in an attempt to adjust the center of gravity. Armstrong is learning how to manage the new airplane's energy. The

GEZA SZUROVY

MICHAEL GOULIAN

PHIL KNIGHT

ELLEN DEAN

The only woman to win an invitational masters championship, she was a part of the team that won the 1988 women's team gold medal and placed second in the women's in 1990, one of four current team members who has done so. "As soon as everybody's minds are adjusted to the fact that we're all equal, we will not need a women's division," she says. "But at this point, I don't believe everyone in the world thinks that men and women are equal [in aerobatics]."

Patty Wagstaff broke the glass ceiling in U.S. aerobatics in 1991 by seizing the overall spot at the U.S. Nationals. "I saw [airshow pilot] Sean Tucker at an airshow right after that, and he said: 'You know, ya gotta win it again.' And I said: 'Well, really?' and he said, 'They're gonna say it was a fluke if you don't. I know how these guys think.' " So Wagstaff went out and racked up two more consecutive national championship titles.

Wagstaff is steadfast in her opinion that there's no gender distinction to be made. "My goal's always been to be the best—not the women's best, not the women's anything," she says. Yet she is aware that in aerobatics, that stance is a distinctively American luxury. Mike Heuer, current president of the international organization that oversees the sport, agrees that the gender distinction is outmoded, but he notes that "we have a very strong feminist movement here, and those movements don't always exist in those countries that compete with us."

Yet he believes discrimination in judging is a thing of the past. "It's not going to be long—and maybe even this year—where we have an overall world champion that is a woman," he says. "It's in the cards. There are so many out there that are training so hard and they're such good pilots that it's just a matter of time."

Betty Stewart agrees that, at least in the United States, judging prejudice is easing. She feels that Wagstaff's victories are due in part to that shift in attitude. But she is still doubtful about the chances of the Aresti Cup going to a woman. "To be quite honest, I don't think it is possible," she says. "But if they did do it, it would probably wake up a bunch of the guys. Big time."

Find the official Web page of the World Aerobatic Championships at www.airspacemag.com/Expo/WAC

big ailerons on the new design seem to soak up airspeed during vertical rolls. But if anyone can master the new Pitts, it's the "gainfully unemployed" airline pilot and mechanic from Georgia, who exhibits an uncanny aeronautical savvy in these matters. Armstrong has a reputation for getting the most out of the equipment, having achieved remarkable success with the S-1C model Pitts early in his career.

It seems paradoxical that the road to success in what is so clearly an individual sport is paved with the bedrock of teamwork. This team realizes, however, that they are stronger and more likely to win working together than apart. To a greater degree than ever before, they are sharing techniques and insights, and as a result morale is at an all-time high. "There's a feeling that we want the entire team to do well," says Goulian. "I know that if I finish 10th in the world and we're world champions, that's fine with me." Rookie Matt Chapman believes that the United States has to be a strong team unit in order to win. "We all don't have to be buddies, we all don't have to drink beer at night," he says, "but when we're here, we have to be team players and support each other in a team effort. If we win as a team, individuals will rise to the top." Only team member Patty Wagstaff sees it differently: "Basically, we're all out there competing against each other for first place in the world."

The award for best individual performance, the Aresti Cup, has traditionally been the most sought after, most prestigious of the World Aerobatic Championship's awards. However, the Nesterov Cup, awarded for the best men's team performance, is the better measure of a nation's excellence. (The women's teams compete for the FAI Challenge Cup, traditionally regarded as less competitive because of the smaller number of female pilots. That's sure to change, however; see "The Gender Factor," p. 57.) The individual standings are subject to uncontrollable circumstances, such as the single day of high winds in the Unknown in 1994, the odd mechanical failure, or a sudden illness. A pilot may enter a half-dozen international contests in order to see the proper conditions to make his best flights and become world champion. The formula for awarding the Nesterov Cup cancels out such caprice. Team championships are based on the best three cumulative scores compiled by a team's members. Therefore, fielding a well-balanced team is the prerequisite for ultimate success in the sport.

But more important to this team than the quest for the Nesterov Cup is the quest for credibility, something that can be achieved only by a combined effort to meet the standards set by the rest of the world. "We're entering a time when it is a world community," says judge Alan Geringer. "The distances that separate us mean less. But in the past the separation between the United States and Europe has been a very divisive thing, the Atlantic Ocean in the middle. We are viewed as outsiders. I think we need to do something to bring ourselves into that community."

Despite the extended training, the Americans still lag behind France and Russia, and no one is prepared to predict an easy victory. "We don't spend as much time in the seat as the French do, or the Russians," Goulian notes. "Xavier [de Lapparent] told me that the year he won the Worlds—1994—he had over 350 critiqued flights. We might have 50. So that's what we're up against."

But the United States, armed with an array of state-of-the-art aircraft, prepared by the most intensive training program in the nation's aerobatic history, and having the rare home court advantage, is well out of reasons for failure. "If ever there is a year we are going to do it, this is the year we're going to do it," Matt Chapman says. "We've got the best talent we've had on this team in a while. We've got more people on this team that are bloodthirsty. Everyone here wants to win the world championships. Those guys are on fire. They can taste it."

With the stakes at an all-time high, the success of the training camp and the new-found cohesion as a team inspire veteran Linda Meyers Morrissey to playful confidence. Near the end of camp, she tosses a velvet gauntlet down before the current champions. "The French are beaten," she says; "they just don't realize it yet."

PATTY WAGSTAFF AND FRIENDS

Let's Make a Deal!

by Bill Thomas

Illustrations by David Peters

We got fighters. You got reindeer meat. We can do business.

A rollout is the aircraft industry's version of a Hollywood movie premiere, and last summer, when McDonnell Douglas unveiled the first of 64 new F/A-18 Hornets it was selling to Finland, show business played a big part. Inside the hangar at the company's St. Louis plant, lights flashed and flags fluttered as VIPs posed for pictures in front of the gleaming fighter. Almost three years to the day after Finland signed the $3.4 billion contract, delivery was right on schedule. "To finally see the plane, well, that's a pretty exciting experience," said Colonel Hannes Bjurstrom of the Finnish air force. Which, of course, was just the way McDonnell Douglas management had planned it.

As company executives made the formal presentation, pointing out all the tactical advantages of the F/A-18, it was easy to be impressed with the sleek example of American know-how parked a few feet away. After all, in tough head-to-head testing the fighter had beaten competition from Russia, Sweden, and France, not to mention U.S. rival General Dynamics (whose F-16 fighter division is now part of Lockheed Martin). In this industry, success is measured by occasions exactly like this one.

Virtually unmentioned during the festivities, however, was a part of the transaction that had little to do with efficient combat. It's something that aerospace companies don't like to publicize and it's called "offset." The term encompasses a wide range of concessions sought by foreign governments that want to earn back, or offset, the huge amounts of money they spend on aerospace goods. Joel Johnson, a vice president of the Aerospace Industries Association, based in Washington, D.C., describes it this way: "A [foreign] country is spending its taxpayers' money in a highly visible fashion on a [U.S.] product, and elective representatives the world 'round like to show jobs for their taxpayers' money. So they say, 'Okay, we're gonna buy your helicopter, we're gonna buy your jet aircraft. But we want at least some piece of the action back here.' "

Offset requests fall into two categories: direct and indirect. Direct offsets are licensing, co-production, and subcontracting deals directly related to the product being exported—for example, allowing foreign factory workers to assemble U.S. aircraft bought by their government. Indirect offsets include bartering of goods and investments in industries unrelated to the exported product. In a classic example of indirect offset, some 30 years ago Yugoslavia purchased a fleet of McDonnell Douglas DC-9s; in return, McDonnell Douglas found buyers for Yugoslavian canned hams, and, in a gesture of goodwill, bought a shipment of Yugoslavian ham to serve in its company cafeterias and executive dining rooms.

FREEZE-DRIED REINDEER MEAT, SAUNA EQUIPMENT, WOODEN FLOWERS— THEY'VE SEEN IT ALL.

"Name a commodity or natural resource anywhere in the world and it's probably been part of an offset package," says Phillip Hough, a Washington, D.C. consultant to the defense industry. Arranging indirect offsets has made aerospace companies the energetic middlemen in business deals involving everything from fuselage parts to frozen pizzas.

Many people, however, would like to do away with offsets. Critics charge that direct offsets hurt the U.S. economy by sending jobs overseas, encouraging technology transfer, and creating future competitors. The companies that arrange the fulfillment of offset requests counter that in today's market, it is the purchaser who dictates the terms of a sale. "You respond to your customer or you don't get business in this world," says Joel Johnson.

"Right from the start, the Finns made it clear that 100 percent offset was a pre-condition of the sale," says Eugene Cunningham, who worked on the F/A-18 sale in McDonnell Douglas' Washington, D.C. office and now manages the company's Finnish offset program by traveling to and from offices in St. Louis and Helsinki. "Every competitor knew whoever won would have to come [to Finland] and get busy."

Lean and focused, Cunningham, a McDonnell Douglas man since college, admits that even for someone as detail-oriented as he is, offset can be "a nuisance," but, he hastens to add, "it's a real challenge too."

Basically, offset works like a corporate dating service: Airplane sellers promise to connect airplane buyers with what one expert in the field calls "compensating economic opportunities." For the F/A-18 deal, McDonnell Douglas agreed to meet 60 percent of the $3.4 billion offset pledge to the Finns, an obligation that has sent Cunningham scurrying to find companies who want to buy Finnish goods. The other 40 percent of the pledge will be fulfilled by subcontractors General Electric, Northrop Grumman, and Hughes, each of whom will build parts of the Hornet.

"It's not enough anymore just to sell airplanes," says Cunningham. "Offset is an unavoidable part of this business, and if you want to succeed, you have to be good at lots of different things."

Every week, Cunningham's prematurely gray-haired assistant Tom Bell holds open auditions to find businesses with products McDonnell Douglas can help market. In theory any Finnish firm can make a pitch. Freeze-dried reindeer meat, sauna equipment, wooden flowers—Bell and Cunningham have seen it all. If Bell likes an idea he passes it on to Cunningham, who rolls up his neatly pressed shirtsleeves and crunches the numbers. The next stop is an offset committee created by the Finnish government, which has to approve every project, then figure out how much offset credit goes with it.

So far, four years into its 10-year contract with McDonnell Douglas, Finland has recovered $1.7 billion in new business because of the offset operation. That's nearly halfway to the goal.

Some 10 percent of the overall total is being absorbed in a direct offset by the Finnish company Finavitec, whose workers (150 of whom received training in the United States) will do final assembly on 57 of the fighters, working from fuselage kits provided by McDonnell Douglas and Northrop Grumman. In addition, McDonnell Douglas' extensive sales network will help Finavitec market its trainer, the Redigo, abroad. The rest of the offset has to be

accounted for by dozens of mostly small- and medium-size companies, most of which have nothing to do with aerospace.

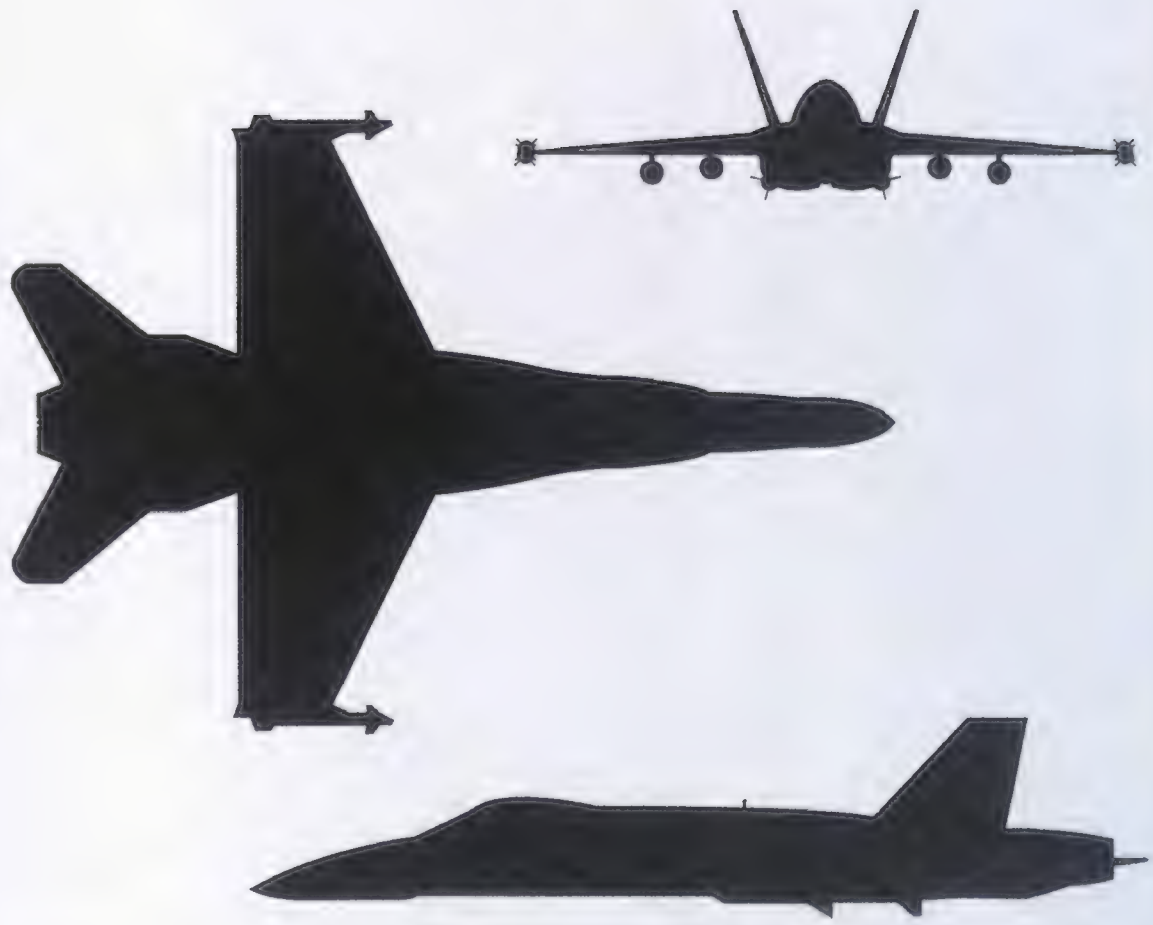
"Before, not many people here thought of doing business in America," says Rikka Palin, vice president of Global Connections, a Helsinki consulting group that packages proposals for Finnish firms applying for offset assistance. "But offset is making Finns think big."

How big? Palin says she represents a Finnish company that wants to market a self-cleaning building; the window washing system is built right into the walls. ("This will be very popular in New York," she predicts.) And an association of Finnish industries known as FINDOC, formed to take advantage of McDonnell Douglas' offset expertise, includes such enterprises as Nokia, a leading producer of cellular phones, and Kone, which manufactures elevators. A much smaller company, Environics, makes testing instruments and used McDonnell Douglas' Washington connections to market a gas detection device to the U.S. Army. "We couldn't have done it without them," says an Environics official. A McDonnell Douglas contract specialist helped write the proposal. But that's all the company or McDonnell Douglas would say on the subject. Offset has that effect on people.

It hasn't always been this way.

Offset has its roots in the 1950s, when the U.S. government actively encouraged the transfer of military technology to Western Europe and Japan. To help these war-ravaged countries rebuild their economies and to support them as allies against the Soviets, the U.S. government set up co-production and licensing agreements for the manufacture of U.S. weapons systems. According to "Offsets in Defense Trade," a report published by the Department of Commerce last May, during the cold war offsets "served important foreign policy and national security objectives of the U.S., such as increasing the industrial capabilities of allied countries, standardizing military equipment, and modernizing allied forces."

By the mid-1970s, U.S. military contractors and their foreign customers were negotiating the kinds of offset deals we see today. General Dynamics sold F-16s to a consortium of buyers from Holland, Belgium, and Denmark



A Fighter for Finland

Despite the obvious economic incentives, choosing to buy an American fighter, the Finns say, was a military decision. (And one not without precedent: In 1939 Finland bought 44 Brewster Buffalo fighters intended for the U.S. Navy; see "The Sorry Saga of the Brewster Buffalo," June/July 1996.) "History has taught us we must stand alone against our enemies," explains General Heikki Nikunen, the former chief of the Finnish Air Force, who was instrumental in his country's purchase of F/A-18s.

Though the Finns insisted that the aggressive-sounding "A" for "attack" be dropped from all references to the aircraft, if necessary, they can achieve a state of full military readiness in a matter of hours. It was important, according to Nikunen, that whatever fighter was chosen fit into Finland's tactical plans. The F/A-18, with its superb combat record in the Gulf war, its ability to be upgraded as technology changes, and, most of all, its performance in winter testing, proved to be just what the Finns were looking for. "To us, a plane is like a car," says Nikunen. "If it doesn't start in the cold weather, what good is it?"

The Pentagon requires that foreign governments buying U.S. military aircraft contract with one of the U.S. service branches for conducting all preliminary tests. Finland hired the Navy, which guarantees the test results and the quality control compliance on all assembly work done in Finland.

When Finland's defense ministry began considering new fighters in 1988, the official directive was to acquire half from Western suppliers and half from the Soviet Union. After the collapse of the U.S.S.R. in 1991, though, the Russian MiG-29 got little more than a brief look before Helsinki decided to buy an all-Western air force.

The choice of the F/A-18 represents another departure from Finnish tradition. Buying American jets meant rejecting the JAS Gripen from Sweden, Finland's oldest trading partner. When the Hornet was chosen, Sweden's defense minister Ander Bjorck complained that the selection was a serious blow to diplomatic relations with Finland. Today, a spokesman for the Swedish Embassy in Helsinki says, "There was disappointment, but no lasting animosity. Everything is forgotten."

Russian officials in Finland are not so forgiving. "No comment," grumbled a surly attaché when asked about the lost MiG-29 sale.

by subcontracting work to them. And Switzerland got a comparable package when it bought F-5s from Northrop (the aerospace company even helped find buyers for Swiss chocolate). There had been similar sales before that—in 1955 North American delivered 221 F-86 Sabre "kits" to Italy for Fiat to assemble—but usually, when a government bought military aircraft, that's all it got.

According to the commerce department report, which is based on information provided by U.S. military prime contractors, in 1993 there were new offset obligations of $4.8 billion based on sales contracts of $13.9 billion, and in 1994 there were $2 billion worth of offset obligations for sales worth $4.8 billion. During this two-year period, $1.9 billion of offset was paid off in a variety of transactions, one-third of which were direct and two-thirds of which were indirect.

The commerce report shows that European countries and NATO allies make the most requests for offset assistance and that they favor job-generating direct offset, but it is the offset transactions requested by countries in the Pacific Rim that have been the most controversial. According to the report, "countries such as Singapore, South Korea, and Taiwan are seeking offset deals that include increased technology transfer, particularly in aircraft design, to become self-sufficient in military production and to overcome industrial weaknesses that are hindering their efforts to compete in the world aerospace market with U.S. and European manufacturers."

Perhaps the most intense criticism of offset aid to Asian countries has come from the International Association of Machinists and Aerospace Workers, a labor union that has lost jobs due to cutbacks in commercial and military aviation and is particularly concerned about the possibility of losing even more jobs to Asian markets. An article that ran in the *IAM Journal*, a union publication, complained: "U.S. aerospace giants don't seem concerned about giving it all away. They feed the Asian tiger, and the competitor grows."

Particularly troubling to the IAM is McDonnell Douglas, which has been building commercial airliners in China since 1985, giving jobs to Chinese workers in the process (see "The Dachang Douglas," October/November 1987). But aerospace executives believe that if McDonnell Douglas hadn't agreed to set up shop in China, the contract would have eventually gone to European arch-rival Airbus. This is little comfort to George J. Kourpias, president of the IAM, who asks: "Who gains if an airplane says McDonnell Douglas on the tail but was built in China, South Korea, Indonesia, or Finland?"

Of course, transferring jobs and technology is nothing new in other U.S. industries, with U.S. companies that manufacture chemicals, computers, and processed foods leading the way. These industries have invested heavily in foreign markets, spending billions of dollars to build overseas factories staffed by foreign workers. So it may be naive to think that the aerospace industry would be any different. Except that guns are not butter—the underlying objection to transferring military technolo-

gy is the possibility that the United States' superior weapons could wind up in the wrong hands. Aerospace executives, however, say that export regulations don't allow them to license military technology until it is at least 10 years old.

"None of our companies has any desire to go out of business," says Johnson. "We have very professional offset managers whose job is to give away as little as possible. There will be certain things they will keep home: certain design techniques, certain engineering programs, and certain components.

"The way to stay ahead is to run faster, not stand around trying to trip the other guy," Johnson adds. "Let him build a souped-up F-16; we're going to go build an F-22."

Technology transfer is, of course, a two-way street. U.S. labor unions have had no qualms about demanding manufacturing jobs and investment from foreign merchants. "We have seen Americans do it in automobiles, steel, semiconductors—where you basically force the foreigners to come in to our own market and build, transfer technology, and move the jobs," says Johnson. "The reformation of the automobile industry was Japanese management and technology. Every American company went and teamed with a Japanese company for several years until we learned what we could learn from them."

And these types of arrangements are not unprecedented in the aerospace industry. "If you look at the Harrier jump jet, a British design, more than half of it's built in St. Louis," says Johnson. "The T-45 trainer, which is a navalized version of the Hawk 100 built by British Aerospace—it's put together in St. Louis. I mean, we're no different. We just don't call it offset. We say: 'We need a [domestic] production line for security purposes.' The Europeans say, 'Quacks like one, walks like one. Looks like a hundred percent offset to us.' "

In military sales, work on offset begins for U.S. manufacturers when foreign governments officially notify the Pentagon they're shopping for airplanes. Even before that, though, industry insiders knew the Finns would need an entirely new air force. Their old fleet, made up of Swedish Saab Drakens and Soviet MiG-21s, was nearing the end of its quarter-century service life. In 1989, as the Finnish Defense Ministry began debating how to pay for the purchase, aerospace firms in Europe and the United States were busy drawing up marketing plans.

By the time actual testing of the various fighters under consideration got under way, offset competition was in full swing. Teams from every company in the running were in Helsinki showing the Finns what they could do. To sell officials on their Dassault Mirage 2000-5, the French company even compiled over a half-billion dollars in so-called "pre-offset," a large part of which involved buying Finnish grain elevators and reselling them to a shipping company in southern France. General Dynamics, which hoped to sell its F-16 fighter, countered by raising its total offset bid to 125 percent of the purchase price, an amount well above what the Finns had asked for. The Finnish Defense Ministry still chose the F/A-18, but only after several pauses that had peo-

ple from McDonnell Douglas sweating bullets.

Their anxiety was understandable. The ripple effect of a lost contract can be devastating. France's failure to sell the Mirage to the Finns resulted in the immediate elimination of 650 jobs at a Dassault subsidiary. General Dynamics said it would have to make similar cuts, and by 1992 the company had sold its F-16 division to Lockheed.

Not every military purchase involves offset, of course. When Kuwait recently bought 40 Hornets from McDonnell Douglas, it paid for them the old-fashioned way. But straight cash transactions, once the industry norm, are now the rare exception. "If you could wave a magic wand, companies would prefer to sell a product off the shelf made in their plant," says AIA's Johnson. "But that's just not the world we live in." And the only apparent way to change the current mode of doing business would be for aerospace companies from *all* countries to agree not to honor offset requests from potential purchasers. But Johnson doubts that such an agreement is likely: "It's so hard to even define what an offset is," he says. "Aerospace is a global industry and you don't want interference that prevents us from carrying on legitimate, non-offset international commerce—and how do you tell the difference?"

Eugene Cunningham says he's starting to feel right at home in Finland. When delivery of all 64 Hornets is finally completed, in the year 2000, he will have spent a good portion of his life there. At first it was hard getting used to so little daylight during the winter, he says, but he doesn't mind it that much anymore. Offset keeps him so busy he hardly notices.

On a typical day Cunningham might be reviewing business proposals in the morning, then talking with officials at the Ministry of Defense, followed by a call to the McDonnell Douglas offset command post in St. Louis. Once a week he visits the Finavitec factory.

On this morning, Cunningham is getting ready for a meeting with the 10-person Finnish offset committee, which sits in judgment over all new projects. A decision on offset credit can take anywhere from a few days to a few months, as the Finns and McDonnell Douglas debate the dollar values of various proposals. "We only take them deals we're pretty sure they'll accept," says Cunningham, who concedes the Finns "play it tough." Some proposals have been turned down, though neither side will say how many or what kind.

It seems that with offset, appearance is everything, and the less said the better. "There's a lot of smoke and mirrors involved in offsets," says one industry insider. "The ultimate objective is to get [offset] credit for what would have happened anyway. Or for [something that] takes only a moderate amount of effort to change from Supplier A to Supplier B—we may buy from a Finnish rather than a German producer, but it would never have been an American producer anyway."

"BASICALLY THE CUSTOMER PAYS. HE MAY NOT KNOW HE PAYS—HE MAY NOT WANT TO KNOW HE PAYS."

The smoke gets even thicker if you try to pin down the true costs of offsets. The prices for aircraft bought under offset agreements are usually substantially higher than aircraft bought off the shelf, and with good reason. "Offsets are not free," says the same industry source. "That's part of the mythology, and many of these countries think it's a freebie. But obviously companies have to get paid for the work they do, and by and large, somewhere in the price of the product is going to be the price of implementing the offsets. Someone's paying for Gene Cunningham to be in Helsinki, and it's not McDonnell Douglas. In the long run, it's going to be the Finns. So basically, the customer pays. He may not know he pays—he may not *want* to know he pays." Of course, all of this becomes acceptable if one remembers that a primary purpose of offsets is to make things look good at home—to make politically acceptable the expenditure of huge amounts of taxpayer money on foreign products.

And sure enough, in Finland everyone is happy with the overall results. Ake Whitol, the no-nonsense offset committee chairman, thinks McDonnell Douglas has performed well, although he admits the American negotiating style took some getting used to. "Our agreements are simple in Scandinavia," Whitol explains. "When we decide to do something, we do it. The American way is to write everything down. I suppose it's the influence of so many lawyers."

Back in Cunningham's office, the phone rings. St. Louis is calling. Mark Sullivan, head of McDonnell Douglas' offset operations worldwide, is on the line. Sullivan oversees offset projects from Canada to Malaysia, and as it turns out, he doesn't really like the word "offset." The preferred McDonnell Douglas term is "industrial participation," and he's anxious to explain the benefits. "We view ourselves as a global corporation," he says. "We have to establish ties with high-quality companies around the world. We do $200 million worth of business a year with over 100 producers in the United Kingdom alone. We have a relationship in aviation with Finland that goes back to the 1930s. Our theory is we could be in business anywhere someday, so we don't cut and run."

Industry executives don't like to talk about promoting future competition and Sullivan is no exception, but he does offer this positive prediction. "I can see a future where there isn't such a thing as offset," he says. "Companies will collaborate on deals, share technology, and divide profits."

He doesn't see that coming anytime soon, however. For now, beating the other guy is still the name of the game. "Sure, we think we're the best," he says before hanging up. "The best in *all* aspects of the business."

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THE LATEST WORD ON TOURS AND LEARNING ADVENTURES

COMMENTARY:

Buried Treasure

Consider the intrepid salvager of historic aircraft, trudging through the ice and snow of Greenland or flippering in the frigid waters of Lake Michigan. After months or years of struggle, he has come upon the stuff of dreams: an intact Grumman F6F Hellcat, say, or a perfectly preserved Lockheed P-38G Lightning. All that remains is to haul the thing off the ice or pluck it from the lake, truck it to the nearest salivating Hellcat or P-38 owner-wannabe, and make piles of dough. With a bit more luck, the future might hold articles, books, even a glorifying spot in a television documentary.

All things considered, such a mini-epic seems the very model of productive adventuring and pluck and, on the whole, rather harmless entertainment. However, to people studying such wreck sites for what they can tell us about the progression of earthbound humans into the dimensions of air and space, or the ways in which our technological society wages war, such salvage adventures often harvest whole bargefuls of unintended negative consequences, none of them very obvious at the time.

It seems like everywhere we turn these days someone is off retrieving another historic aircraft for restoration or sale or both. These expeditions are often organized, mounted, and patronized as "aviation archeology." But is there such a thing? If so, what is it? And does it have any scientific kinship to pursuits such as, say, the excavation of the famous prehistoric mounds of the Ohio Valley or the block-by-block clearing of the buried Roman cities of Pompeii or Herculaneum?

These questions are being asked more and more frequently as aircraft salvage operations meet with either great success or disastrous failure. More often than not, it seems, aircraft salvagers destroy the very thing they seek. In 1986, salvagers discovered a Handley Page Hampden bomber in 600 feet of water near Vancouver, British Columbia, the sole intact survivor of 160 produced in Canada during the second world war. Items that could have revealed details of bomber training in the war were recovered without their positions being recorded. What hand-held and cockpit instruments had been in use, for example? What were their settings? And had they been working? Far worse, during the salvage the aircraft itself was torn to pieces.

More recently, in an attempt to retrieve a Curtiss F9C-2 Sparrowhawk from the wreck of the Navy airship *Macon*, salvagers wrenched apart sections of the airship instead. Last summer, after half a century undersea, a Consolidated Vultee B-24 Liberator was plucked from the bottom of the Mediterranean with the remains of three crew members still on board. No one seems to have been concerned that the recovery was undertaken before even a rudimentary recording of the position and condition of the aircraft or the human remains inside had been completed.

A hundred years ago, Heinrich Schliemann furiously dug to the bottom of the great mound at Hissarlik in Turkey, seeking the lowest level of human occupation, where he was certain lay the site of his beloved Homeric Troy. But in his haste he dug too deep and destroyed the very place he had dedicated his life to finding. The difference between recent aircraft salvage efforts and Schliemann's excavations is that Schliemann did not have a century of archeological survey and exploration methods to draw upon. The modern salvagers of aircraft have no such excuse.

To understand what these methods are and how they are used, one must first understand what it is archeologists do. Archeologists study things people make and the ways in which these things can change our behavior by making our bodies and our brains more adaptable to our world. To simplify things, it is enough to say that archeologists study the evolution of the human body by finding clues to how humans have come to dominate their environment so completely. They study the evolution of the human brain by looking at the material things the brain conceives, the objects of culture that lay all around us. (Culture is a loaded word; I like to de-

ALAN E. COBER

P.J. Capelotti urges us to rethink historic-aircraft salvage, considering not what we gain but what we lose forever.

fine it as what most of the people are doing most of the time.) Whether it's a Roman waterworks, a stone statue on Easter Island, or a British shipwreck in Bermuda, an archeological artifact can tell us what it was like to be a participant in that particular society at that particular time.

The way such sites yield information is by studying them in terms of the two most important concepts in archeology: "context" and "association." These are code words for the relationship of objects in time and space. You can think of context as a vertical or chronological idea: what happened before, during, and after the creation of those objects. The undersea wrecks of the U.S. Navy airships *Akron* and *Macon*, for example, testify to the context of the military's fear in the 1930s that a carrier-based attack would be mounted from the western Pacific (and in this case, of course, the fear was entirely justified).

The challenge for archeologists who want to study aircraft is a large one. Thousands of sites exist where operational aircraft have been brought to earth by accident or design. When this happens, the aircraft leaves the realm of history and enters that of archeology. It has been taken from the air and made a part of the land or the sea. It has found, to use that all-important word in archeology, a new context.

Association is more of a horizontal or spatial term: the spread of the sweet potato across the Pacific islands, for example, or the array of radar installations along the British coast that helped turn back the Luftwaffe in 1940. By placing aircraft wreck sites in association with one another, we can contribute to historical debates regarding, say, the success or failure of British radar against the He 111; or the He 111 versus the Ju 88; or, even more complex, the extent to which a society under the stress of total war salvages and recycles the weapons hurled against it.

These sites, if examined with a view toward what their context and association can tell us, can speak to us directly from the past. The wrecks of the great naval airships fairly shout of the ways our grandparents and great-grandparents sought to provide a defensive screen for their culture (and for us, their biological and cultural heirs), even amid a crushing financial depression. Such sites can enrich our understanding of ourselves and our culture—a far greater reward, I believe, than what the salvage of them whole or in pieces might provide to a few individuals monetarily or materially.

Aircraft salvage adventures often harvest whole bargefuls of unintended negative consequences.

Aircraft and spacecraft are a vital part of our modern technological culture. Many of us fly more or less frequently in commercial jets, and while only a few of us fly in spacecraft, we all pay taxes so that the government can take those risks for us. Our aircraft wreck sites therefore represent a large piece of who we were at the time of the wreck. They are also now a part of the landscape where they came to rest. In these contexts and associations, they have much to tell us about who we are and where we might be going.

No one can eradicate aircraft salvage. And I don't want to. But salvage without documentation is destruction. In any case, there will never be enough professional archeologists to sort through the thousands of aircraft wreck sites around the world. There is, however, a long and generally honorable tradition of amateur assistance to archeological endeavors, so there is no reason why the irreplaceable amateur cannot be trained in the rudiments of historical research and archeological analysis to examine and catalogue the site before the salvager takes over.

These sites need to be read like the books they are, without first tearing the pages out, or selling them off piecemeal at a fire sale, or consigning them to a bonfire. Through the digital abilities of regional and global geographic information systems, archeology now has the tools to register every cultural resource on the planet. If all aircraft wreck sites were accorded this rudimentary recording in a central repository, no matter what their final disposition, they would be registered in this database as part of the natural landscape forever.

But where does all this lofty intellectualizing leave our intrepid aircraft salvager? No doubt burning with resentment at academics trying to keep all the neat toys to themselves, and hotter than the fire started when an attempt to refurbish and fly a B-29 off the Greenland ice cap led to its complete destruction and abandonment by those who sought to retrieve it. And therein lies the difference between aviation archeologists and aviation salvagers who call themselves archeologists. One group studies aeronautical wrecks, the other creates them.

This spring the author received the first Ph.D. ever awarded in aerospace archeology, from Rutgers University in New Jersey. He is a Fellow of the Explorers Club and author of *Explorer's Air Yacht: The Sikorsky S-38 Flying Boat* (Pictorial Histories, 1995).

Who Made the Mustang?

NASM

Most historians agree that the P-51 was the best fighter of World War II, but questions about its parentage persist.

by Peter Garrison

Early in 1930, a German-born engineer of Austrian extraction arrived in the United States from Brazil, where he had lived since 1925. Short, with craggy features and a shock of black hair, the ambitious émigré from post-Versailles Europe would keep a thick German accent all his life. By the account of those who knew him, it gave a professorial impressiveness to his speech.

His name was Edgar Schmued. Born one day before the turn of the century, he had grown up under the tutelage of a devoted father to become a mechanical engineer of considerable ingenuity. By the age of 23 he already held several German patents for gadgets related to automobile engines. In Brazil he had worked for General Motors as a field service manager in São Paulo, but America lured him with an opportunity that he had craved ever since, at the age of eight, he had seen a Wright flying machine pass overhead. America meant a chance to design airplanes.

"I decided, right then and there," Schmued later wrote of the glimpse of the Wright, "that this was for me. This was going to be my life." It was a precocious decision for an eight-year-old, but his intuition was right. Aviation would be his life, and it would also give him a small share of immortality.

In the late 1920s General Motors had created a holding company, North American Aviation, which initially existed only to acquire stock in aviation-related companies. NAA acquired the Fokker Aircraft Corporation in 1929, and it was there that Schmued went to work. Hardly had he arrived when GM dissolved Fokker and reorganized it as the General Aviation Corporation, all of whose shares were held by North American Aviation. Schmued prospered at General Aviation; by 1933 he was project engineer on a large twin-engine observation plane, the YO-27.

Then came a turning point. The Air Mail Act of 1934 forced airmail carriers to divest themselves of airframe-manufacturing holdings. This landmark piece of pro-competitive leg-

Research on new airfoil shapes paid off in the Mustang, a fighter that would escort bombers over great distances.

NASM

islation had historic consequences. For one, it opened the way to Donald Douglas' eventual and long-lasting domination of airline manufacture; for another, it obliged General Motors to relinquish control of North American Aviation, which ceased to be a mere holding company and took over the entire manufacturing operation of the General Aviation Corporation.

The president of the reincarnated NAA was James H. Kindelberger, known, for no logical reason, as "Dutch." He had come to GAC from Douglas the previous year. Kindelberger now hired away another Douglas man, John Leland Atwood, as his vice president and chief engineer.

Lee Atwood was a tall, slim, refined-looking man with chiseled features, a lofty, intellectual forehead, and a bent for mathematics. Trained as a civil engineer, he had been hired by the Okay Airplane Company of Oklahoma in 1929 to design a two-seat monoplane. The Depression had swept Okay away, and Atwood had gone to Douglas in Los Angeles as a mathematical analyst and component designer.

He was still there when Kindelberger invited him to North American, where he played a principal role in the design of the new company's first product, the NA-16 trainer. Initially an open-cockpit two-holer, the NA-16—whose wing reveals the Douglas connections of its creators—would soon acquire a greenhouse canopy and retractable landing gear. Eventually it became the ubiquitous AT-6, the main Army Air Forces trainer of World War II.

In 1935 Kindelberger moved NAA to California, setting the company up on a 20-acre, $600-a-year site where Los Angeles International Airport simmers today.

For Atwood, it was an easy return to turf familiar from his days at Douglas. For Schmued the move was more difficult. His wife Luisa did not want to go to California, so Schmued left NAA for Bellanca, based at New Castle, Delaware. He soon regretted the decision, and since Kindelberger still wanted him, Schmued, his wife, and their 14-year-old son Rolf set out by car for California late in 1935.

Perhaps Luisa Schmued had had a premonition about Los Angeles. A hundred miles east of the city there was a collision on the highway; Luisa was killed. Seriously injured, Schmued did not return to work at North American until February 1936.

Significantly for the future of the company, the British began ordering AT-6s in 1938, christening them Harvards. The British also ordered P-40 Warhawk fighters from Curtiss. The demand for war materiel was rapidly rising, and the manufacturing potential of the United States was unsurpassed. Great Britain set up an office, the British Purchasing Commission, in Manhattan. Because of the success of the Harvard, Kindelberger and Atwood developed a close relationship with the British. Atwood was then in the process of moving out of engineering and into management as Kindelberger's right-hand man, but he still took an active interest in the engineering department, which was now headed by Raymond Rice.

NAA

In 1939 North American designed what was to be the B-25 Mitchell bomber, famous particularly for its part in the 1941 Doolittle raid on Tokyo. The airplane won an order from the U.S. Army Air Corps. Edgar Schmued, still a junior figure at North American, played a minor part in the design of its bomb racks; later that year, however, he was project engineer on a handsome but abortive two-seat tandem primary trainer, the NA-35. By 1940 he had become NAA's chief designer.

Schmued longed to design a fighter. He was in the habit of designing "ideal" portions of hypothetical airplanes, and had sketched a light fighter that in general appearance lay somewhere between the sleek primary trainer of 1939 and the Curtiss P-40, at the time still the best American fighter in series production. The British, meanwhile, were ordering

more P-40s than Curtiss could build. Early in 1940, the British Purchasing Commission floated the idea that North American might set up a supplemental P-40 production line.

Lee Atwood was making frequent trips to New York to meet with the British, sometimes accompanied by Kindelberger and Schmued. North American would have preferred to design a new fighter, or at least modify the P-40, rather than try to set up production for another firm's aging design. But the notion of selling the British a completely new fighter design "seemed somewhat fanciful," Atwood recently wrote, "since I had never seen any government buy a production plane without a set of requirements in detail, some kind of competition and/or flight test approval and a formal appropriation of money."

SAN DIEGO AEROSPACE MUSEUM LIBRARY

"Dutch" Kindelberger (opposite, top) led North American Aviation on the power of charm and charisma.

The Royal Air Force, the Mustang's first customer, provided a final touch: the Rolls-Royce Merlin engine (opposite).

Edgar Schmued (above), a German born Austrian, brought a classic approach to design when he joined NAA in 1936.

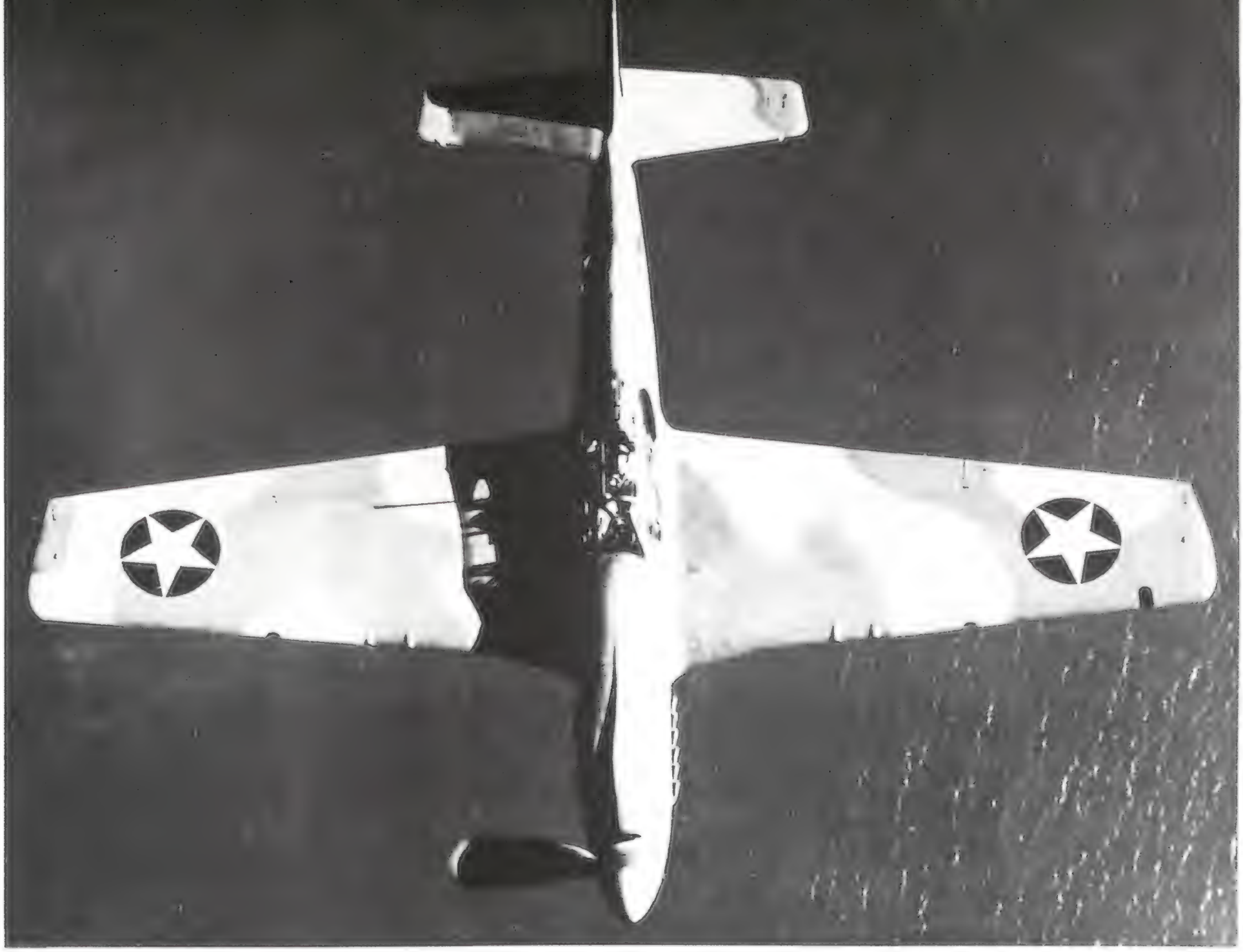
Nevertheless, early in 1940 the shape of a new fighter was on many minds at North American. The starting assumption was that the new airplane would be a P-40 replacement, using the same engine and having approximately the same size and armament but achieving superior performance. The P-40, which could reach about 350 mph with its weakly supercharged 1,000-horsepower Allison engine, was already obsolescent; the prototype, which had been ordered in 1937, had actually been a re-engined version of an even older, radial-powered design.

Inline and narrow-V liquid-cooled engines had an obvious advantage for airplanes: They allowed for a far more streamlined nose. But air still had to flow over some kind of heat exchanger in sufficient quantity to cool the engine, and the drag reduction won from a more streamlined cowling would be lost if cooling airflow were not properly controlled. The treatment of the cooling radiator was the crux of the design of liquid-cooled fighters. None of the early liquid-cooled fighters—the P-40, Spitfire, Bf 109, Hurricane—had dealt very elegantly with this problem. A lot was at stake; fully 10 percent of the total drag of an airplane could typically be blamed on engine cooling.

The problem was that in order to reduce drag, which increases with the square of speed, and also keep the air in contact with the radiator long enough to allow heat transfer, it was necessary to slow the air passing through the radiator. The lower the velocity of the air for a given mass flow, however, the larger the cross-section of the radiator and its associated ducting had to be. The ideal radiator was so large that it would barely fit in the airplane—certainly not in the small underwing ducts used on the Spitfire and Bf 109.

Every possible location for radiators was tried. Indeed, the prototype XP-40 of 1938 carried its radiator in almost the same place as the P-51 would, as did the Curtiss XP-46, a proposed—but discarded—P-40 replacement built in 1940. No position had yet displayed a convincing superiority to any other. But Lee Atwood believed that pay dirt would be found there somehow, and he was mulling over this and other fighter design problems early in 1940, as were other engineers at North American who knew that a fighter project might be in the offing.

Today this rather esoteric question of radiator placement is the fulcrum of a controversy over the genesis of the Mus-



NASM (2)

The P-51 (above) looked like a first cousin to the Curtiss P-40, but its performance was a world apart.

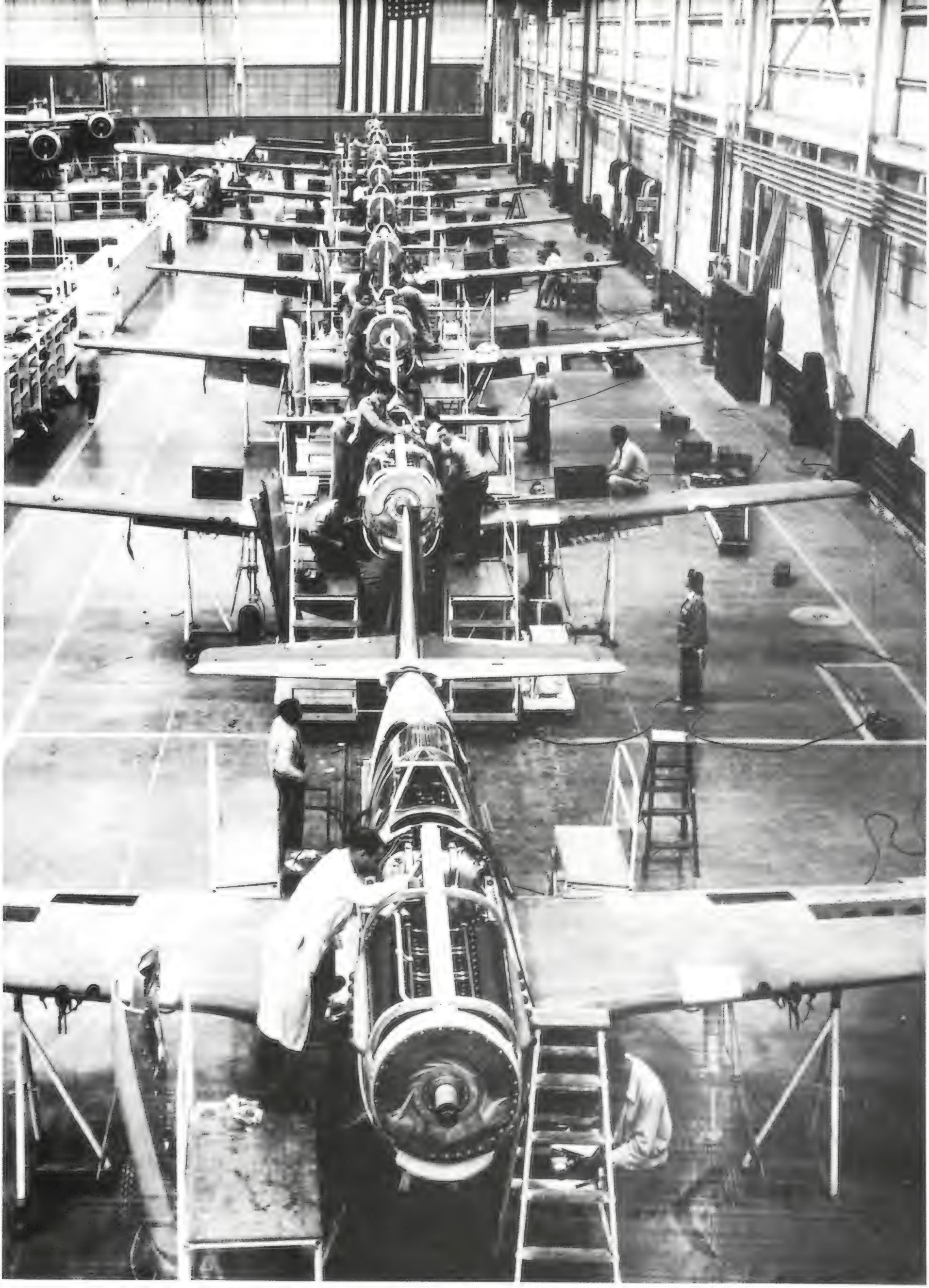
NAA engineered the Mustang to be easy to build, and its production lines were among the most efficient of the day.

tang. In a 1993 article in the historical journal *Air Power History*, Lee Atwood asserted that the idea of placing the Mustang's radiator behind the pilot—a decision that in many ways defined the rest of the design—was his. He relates that he had seen papers from the Royal Aircraft Establishment at Farnborough reporting on experiments with radiator ducting. A scientist named Frederick W. Meredith had provided a theoretical basis for a drastic reduction in cooling drag. The principle was similar to that of the jet engine: Heat imparted to the incoming air would make it expand, requiring that the outlet be larger than the inlet. The result, assuming roughly constant total pressure in the duct, would be a modest thrust. A long duct, gradually expanding ahead of the radiator and gradually converging behind it, was essential—the ideal duct, in fact, would have been as long as the entire airplane. While it might be utopian to expect a *net* thrust, Atwood hoped that what he came to call "the Meredith effect" would offset some or even most of the cooling drag.

Atwood's article brought a rebuttal from aerodynamicist Ed Horkey, who had come to North American from the California Institute of Technology in 1938 to work under Schmued. The aft location, he said, was an obvious choice; there was no room for a suitable radiator anywhere else. Neither he nor Irv Ashkenas, another Caltech-trained aerodynamicist who worked on the Mustang, remembers Lee Atwood having had a role in that decision. Horkey dismisses the algebra that Atwood used to explain the Meredith Effect to the lay reader with the words, "We used calculus." The British Purchasing Commission, Horkey thinks, was impressed less by the Meredith effect than by Dutch Kindelberger's magnetic personality and Ed Schmued's German accent.

This disagreement, surfacing more than half a century after the fact, is emblematic of the personal politics of NAA at the time. The engineering department was divided, with Atwood and chief engineer Raymond Rice on one side and Schmued and the rest of the aerodynamics staff on the other. Edgar Schmued's son Rolf says his father actively disliked Raymond Rice, while Atwood, who seemed haughty and reserved alongside the charismatic Kindelberger, was merely "not his favorite person." Schmued's persistent animus toward Rice is evident in his 1985 memoir of the Mustang design days, prepared for historian Ray Wagner. In this account, Rice emerges as either remote from Mustang development or skeptical of Schmued's design decisions and choice of collaborators.

Horkey today depicts Schmued as a brilliant designer entirely capable of creating the Mustang, both because of his natural talents and because of his exceptional willingness to solicit input from other specialists, particularly aerodynam-



DAVID BUTOW

Lee Atwood (above) recalls that in the 1940s, development of a new fighter in 102 days was not considered exceptional.

Ed Horkey (below) recounts events and roles differently from Atwood, but there may be elements of truth in both versions.

Irv Ashkenas (right) moved the air scoop's intake away from the roiling boundary layer, and his "gutter" is still in use.

icists. Atwood paints a less charitable picture of his abilities. Schmued, Atwood says, was not a full-fledged aeronautical engineer but rather a self-taught draftsman with "a real talent for shapes and arrangements." This condescending characterization, though somewhat implausible in light of Schmued's long and illustrious career, leaves room for Atwood's claim of responsibility for the Mustang's basic technical feature. Schmued was, Atwood asserts, "out of his depth" when he left NAA in 1952 to head the T-38 program at Northrop.

Atwood repeatedly discussed his fighter ideas with the senior technical man at the British Purchasing Commission and also, whatever his estimate of the chief designer's abilities may have been at the time, with Schmued himself. Not a person given to idleness, Schmued took the hint, and when Atwood returned from New York in April of 1940 with the news that the British had accepted his proposal for a new fighter and had ordered 320 aircraft, the designer was ready. Kindelberger, whose estimation of Schmued's abilities was evidently higher than Atwood's, put him in charge of the project.

DAN COOGAN

In order to provide at least an appearance of continuity between this and previous fighter acquisitions, the British stipulated that NAA was to purchase from Curtiss the flight test and wind tunnel reports on the XP-46. NAA acquired these for $56,000; Atwood, who made the trip to Buffalo to collect the box of papers, found Curtiss general manager Burdette Wright "reasonable enough, considering the competitive aspects." Horkey, then chief aerodynamicist, looked the materials over. He found them "obsolete and very amateurish" and promptly filed them. Schmued supposedly never saw them and designed the P-51 on a clean slate. Nevertheless, the P-40 must have served as a basic pattern for the Mustang; the similarity in overall dimensions, areas, and general arrangement between the two airplanes is too close to be coincidental.

The cockpit layout was Schmued's work; he had defined the "ideal" fighter cockpit long before the Mustang project—NA-73—was born, and a mockup was completed within a couple of weeks of the contract's being let. The original Mustang had a high upper fuselage aft of the cockpit, like the P-40's; it was not until the D model of 1943 that the more familiar bubble canopy appeared. Thanks to the narrow engine, the fuselage could be less bulky than that of the radial-descended P-40, and the wing was slightly modified at the root to accommodate a fully enclosed inward-retracting landing gear in place of the P-40's partially exposed aft-retracting system. The radiator inlet was under the wing center section—where it was always aligned with the airflow, regardless of the attitude of the airplane—and the outlet was halfway back along the tail cone.

The Mustang had several other novel characteristics. The tips of its flying surfaces were squared off at a time when rounded tips were believed—incorrectly—to provide lower drag. This idea for simplifying production of the P-51 came from Schmued and Horkey but was based on pre-war German work; that the design in fact incurred no drag penalty was validated by wind tunnel tests, as was the general performance of the laminar flow wing.

The laminar flow airfoil (see "Go With the Flow," June/July 1995) used on the Mustang's wing—the first time one was employed on a military airplane—was based on reports from Russell Robinson, an aerodynamicist with the National Advisory Com-

FRANK KULCZAK

The Mustang's cooling system employed a large scoop with a fixed inlet leading to a chamber that allowed the cold air (blue) to expand rapidly and reduce its velocity before passing through the hot radiator. Slowing the air's passage helped to provide an efficient transfer of heat, which added energy just as a turbojet's combustor does. Aft of the radiator, the duct narrowed, and a movable flap controlled the exit pressure. As the heated air (red) converged and exited, its velocity contributed enough thrust to offset approximately 90 percent of the cooling system drag.

mittee for Aeronautics, about successful wind tunnel experiments on a new family of low-drag airfoil shapes. These profiles were back-calculated from a desired pressure distribution intended to delay the onset of turbulence; a crew of mathematicians with electrical-mechanical calculators, led by Ed Horkey, spent weeks on the job, one which can now be done by any home computer in a few seconds. (Interestingly, it was subsequently noticed that laminar airfoils bore a strong resemblance to the cross-section of a trout; natural selection had beaten the NACA to it.)

Another characteristic feature of the Mustang was the boundary layer gutter that separated the cooling air intake from the fuselage. Schmued had originally designed the airplane without the gutter, and with a variable-area entry and exit on the cooling duct. Flight testing revealed an explosive hammering noise emanating from the duct. The noise was caused by the duct's intermittently ingesting the boundary layer—the sheet of turbulent air close to the skin of the airplane—along with the smoother, faster air farther from the skin.

Aerodynamicist Irv Ashkenas came up with the idea of moving the entire duct away from the belly skin so that its inlet was in an undisturbed stream of high-speed air. A "gutter" about an inch and a half deep carried the turbulent, low-energy surface boundary layer air clear of the inlet. This arrangement became classic; the F-16's underbelly scoop is reminiscent of the Mustang's. Once the entry design was perfected, the variable-area inlet feature was dispensed with; an adjustable chute at the aft end of the duct controlled the volume of air flowing through it.

The matter of the boundary layer gutter provides an interesting illustration of a phenomenon that historians must constantly encounter: contrary yet plausible versions of an event from equally authoritative sources. Schmued reported that it was suggested to him by Rolls-Royce aerodynamicist D. B. Shenstone, who visited NAA early in 1941, while Ed Horkey insists that it was Irv Ashkenas who came up with the idea. In fact, both versions may be true, just as both the Atwood and the Horkey-Schmued versions of the radiator placement decision may be true. Ideas move about among people like air, often unnoticed; the parenthood of an idea is sometimes very hard to establish, and it is common to adopt a foundling and later to believe it one's own.

DAVID HEFTOW

An important element in the Mustang's superior performance—late models could top 490 mph in level flight and had a cruising range of up to 2,400 miles—was overall surface cleanness. The importance of a smooth skin was becoming clear from NACA work; any hope of attaining laminar flow, particularly, required exceptionally precise workmanship. It was Schmued's idea that every rivet in the airplane be set flush with the skin. North American had good metal fabricators, and Dutch Kindelberger was a production man at heart. Mustangs started clean and became

NASM

cleaner—if one ignores the bulbous underwing ferry tanks they were forced to carry in their role as long-range fighter escorts. In contrast, the prototype Curtiss XP-46 was a mass of bumps, seams, vents, and intakes, and it lagged behind similarly powered early Mustangs by 30 mph.

The creation of a complex machine like the P-51 is always the work of a group. Aerodynamics, structures, weights, tooling, production—they all play parts, often imposing conflicting demands on the chief designer. North American was exceptional those days in the degree of cooperation between departments, a state of affairs that was due in part to the personality of Ed Schmued and in part to the presence of a first-rate technical man, Atwood, in top management. Personal animosities, which would lead to Schmued's resignation many years later, were submerged then in the drive to get the airplane done. And done it was, in 102 days—a period that seems miraculous today, but that was not, according to Atwood, unusual at the time. (Irv Ashkenas remembers the tempo during the development of the Mustang prototype as "relaxed.") In any case, it was done sooner than the engine supplier expected; the finished airframe had to wait 18 days for the delivery of an engine.

But if the airplane was a team effort, its character was the work of a single man. No one disputes that that man was Edgar Schmued.

Schmued defined the form of the Mustang with the boatbuilder's classical method of second-degree conics. He used a geometric construction originated by the 17th century French philosopher Blaise Pascal to generate curves belonging to a handsome family that includes the ellipse, the parabola, and the hyperbola. Schmued believed, with a Pythagorean faith in the underlying kinship of Number and Nature, that these fundamental geometric curves were "friendly" to moving air in special ways. "This is the kind of shape the air likes to touch," he said. He used them to lay out a form of purity, simplicity, and elegant proportion. Later, Roy Liming, an NAA mathematician and loftsman—lofting is the creation of full-scale drawings from which production tools are made—would translate the graphic conic-lofting procedure into mathematical terms so that all approximation evap-

SAN DIEGO AEROSPACE MUSEUM

orated from the definition of a compound-curved aerodynamic surface. Liming would boast, with pardonable hyperbole, that the Britain-based Mustangs could fly to Berlin and back because their surface contours did not deviate from the mathematical ideal.

It was actually not North American but the British who in 1942 put the final stamp on the Mustang by replacing its asthmatic 1,150-hp Allison engine with a 1,650-hp Rolls-Royce Merlin. The Merlin's two-stage blower gave the Mustang the power at altitude that it needed to become the fastest fighter of its time; it also allowed the removal of the unsightly carburetor air intake from the top of the long cowl. The technicians at Rolls-Royce came up with a series of horrible-looking cowlings for the experimental airplane on which they mounted the first Merlin; it wasn't until North American began installing Packard-built Merlins in Mustangs at Los Angeles that Schmued's conics restored to the airplane the patrician profile whose grace and elegance surpassed every other fighter's.

The early years of World War II were a golden age for airplane manufacturers. Beneath the battlefields and the struggle for victory flowed a river of money. The weapons manufacturers were like prototype shops or the studios of artists, where individual genius mingled freely with cooperative enthusiasm. Lee Atwood, using the terminology of a business executive, would later write of that time, "I doubt that I shall ever see again such a degree of product improvement, employee participation, relative product value, economic production, and generally superior results as I experienced in Dutch Kindelberger's airplane production complex during the period 1939 to 1945."

North American's heyday began with the AT-6 and continued beyond the Mustang: The next great American fighter was another NAA product, the F-86 Sabre. Ed Schmued remained with the company until 1952, when the personal politics had developed into a maze of rifts that still appear in recollections of the Mustang years today. After a brief period as a private consultant he went to Northrop, where he headed the T-38 development program before returning to private consultancy in 1957.

Lee Atwood became chief executive of North American after Kindelberger retired in failing health; he remained at the helm as the company entered the era of computers, cruise missiles, earth satellites, and moon rockets, retiring after its 1967 acquisition by Rockwell International. Now 91 years old and still healthy and active, he lives in Pacific Palisades, California. An indefatigable writer with an admirable prose style, he keeps up a prolific and eloquent correspondence with aviation enthusiasts and historians.

Ed Schmued died in 1985 in Oceanside, California. Two weeks later, after an airport memorial service, a flight of Mustangs, their drone mingling with the antiphonal blare of a single F-86, carried his ashes above the site of the old North American plant where the Mustang was born. They then turned westward, and scattered them over the Pacific.

The Mustang's final combination of engine, wing, cooling, and finish made it arguably the best fighter of the war (left). With almost 8,000 built, the D model was the one produced in greatest numbers as well as the most remembered.

>SIGHTINGS<

In the lens of photographer Eric Schulzinger, the Lockheed Martin YF-22 prototype (right) and its cockpit lighting simulator (above) are more than mere machines. "My objective is to treat aircraft and technology as fine-art subjects," says Schulzinger, who as a Lockheed Martin photographer has a wealth of such subjects to work with. "The challenge is to find the hidden art in the design." Many find the likeness of *Star Wars*' Darth Vader in the cockpit simulator, and the shadow-swathed prototype of the Advanced Tactical Fighter could well be Lockheed's version of the Millennium Falcon.

No You Weren't

I Was Amelia Earhart *by Jane Mendelsohn. Alfred A. Knopf, 1996. 146 pp., $18.00 (hardcover).*

Poor Amelia Earhart. Ever since she disappeared, her soul has had to endure the torment of a rash of nonfiction works proposing to solve the mystery once and for all. And now this overheated, overbearing, over-praised novel joins them. Author Jane Mendelsohn's Earhart is dark, brooding, and afflicted with a death wish; then, when she and navigator Fred Noonan crash-land on a desert island, the situation deteriorates into a cross between *Gilligan's Island* and a middle-aged *Blue Lagoon.* Personally, I was hoping more for *Lord of the Flies.*

This book has it all, even a convincing argument against reincarnation. There is foreshadowing troweled on thicker than adobe, though only the densest reader wouldn't have a clue about Earhart's fate. There is also a pretentious, phony-profound solemnity reminiscent of a sophomore fiction writing class, plus reams of torrid prose: "I watch the sky as it curves and swells...voluptuous, sultry in the naked heat, it seems to me to be the flesh of a woman." Gee, why hasn't it ever been like that for me?

As mercifully short as it is, by page 20 I had the distinct impression that the book was already too long. And lest I lose myself in a diatribe on the prose alone, there are some interesting technical errors that made me chuckle when I suppose I should have been breaking into a cold sweat. With a heroic abandon last displayed by Walter Mitty, Mendelsohn has a lost and thirsty Amelia tapping a "dial" and crashing a trainer when the "engine" stalls. A real pilot might call those complicated-looking thingies "instruments," and would probably know that it's the airplane's wing that stalls, not its engine (of which a Lockheed Electra always has two). If you really are Amelia Earhart, Mendelsohn, it's no wonder you got lost.

—Phil Scott holds a national speed record for flight between New York City and Martha's Vineyard, though to be fair he had little difficulty navigating between either island.

DAVID CLARK

Engineering the F-4 Phantom II: Parts Into Systems *by Glenn E. Bugos. Naval Institute Press, 1996. 264 pp., photos and drawings, $29.95 (hardcover)*

In September 1953, engineers in the advanced design office of McDonnell Aircraft submitted a proposal to the U.S. Navy's Bureau of Aeronautics for what would become the first iteration of the F-4 Phantom II, one of the true success stories of the Jet Age. The proposal was nothing more than an improved, twin-engine version of the Navy's mid-1950s all-weather fighter, the McDonnell F3H Demon. But Navy engineers were intrigued by the idea of a new twin-engine aircraft. The Navy's letter of intent contained very little direction, but McDonnell Aircraft founder and president J.S. McDonnell detected "a gleam in the customer's eye" and put his team to work.

The goal of this book is to show how the people who built the military-industrial complex intended it to work, and to "give their aspirations voice," a goal that author Glenn Bugos achieves in admirable fashion. With the complex, esoteric jargon of the designer, engineer, bureaucrat, and systems analyst, Bugos weaves his way behind the scenes: from drawing board to board room, assembly line to flight line, exploring every facet and nuance of airframe/engine/systems development—including engineering management, operations, and, of particular interest, the unique, complex relationships that developed between the United States and each of the nations that bought or leased Phantoms.

It is a fascinating journey, but, regrettably, in many respects, disappointing. Bugos devotes considerable time, energy, and painstaking research to areas that few, if any, Phantom researchers have visited before. But when he departs from the worlds in which he seems comfortable—systems engineering, logistics planning, configuration management, etc.—Bugos is in trouble. In areas where facts are readily available and verifiable—people, places, events,

On the Web

Flyte Trax, *a Web site, address http://www.amerwxcncpt.com/*

Few applications of the World Wide Web are as impressive—or as much fun—as this one. When you call up the Flyte Trax query page, you first fill in the airline and flight number, then the destination and state. One mouse click initiates a search, and after about half a minute, up pops a map of the United States with a little airplane on it indicating where your selected flight is right now.

Some rough edges still need to be smoothed out for this new service, formulated by partners American Weather Concepts and Flyte Comm, but as a concept Flyte Trax is hard to beat. We first searched American Airlines' Sabre reservation database to obtain flight numbers, times, and city pairs, then tested those in the Flyte Trax Web site. Be warned that entries must be accurate and match the rules (on another reference page), and although we were very careful, about half the entries did not produce a result. The company says it is still refining the service.

Pricing for the service is still being formulated, and special variants will become available to corporate operators who want to track their own aircraft fleet as well as small airport operators who rent aircraft to the public, the company says. The competition is the airlines themselves, who have free 800 numbers you can call when you want to learn the status of that early morning flight your Uncle Fred is on. But the airlines have earned a reputation for fudging when there are delays, and nothing has the impact of seeing a picture of Fred's airliner right there in the middle of Ohio along with a line of text predicting how much flight time remains before he lands. Four stars!

—George C. Larson is the editor of Air & Space/Smithsonian.

things—inaccuracies and half-truths are so prevalent that one must question the authenticity of the more insightful parts of the book. Bugos' reference to mounting "World War II-vintage APS-19 radars…under the wing of the jet-powered F6F Cougar" during the Korean war is a typical example: The F6F was the Hellcat, not the Cougar, but it was the (propeller-driven) F4U-5N Corsair that used the APS-19 radar. It is unfortunate that such inaccuracies substantially detract from what is otherwise a commendable and very worthwhile effort.

—Former naval aviator E.T. Wooldridge is serving as an aviation consultant for the National Air and Space Museum.

Encounter With Tiber *by Buzz Aldrin and John Barnes. Warner, 1996. 576 pp., $21.95 (hardcover).*

Some visions of the future are grounded in the events and objects of today, and space buffs will recognize in this science fiction collaboration some names and ideas that are floating around NASA right now. Buzz Aldrin may not be running a space program, but if he were, you could read his master plan in the opening chapters. Among the events he anticipates is the emergence of an imaginative space transportation system driven by a strong, well-connected entrepreneur. Readers of *Air & Space/Smithsonian* will also recognize in the book's Mars "cyclers" the system of looping conveyances linking Earth and Mars that Aldrin described in these pages (see "The Mars Transit System," Oct./Nov. 1990). Robert Zubrin, who conceived of a new way to get to Mars (see "Mars Direct," Apr./May 1994), is honored by having his name attached to a habitat module.

But Aldrin's collaborator is science fiction author John Barnes, so *Encounter With Tiber* departs from reality soon enough. When a radio signal received from a source near Alpha Centauri is decoded, it turns out to be a "movie" made many millennia earlier by two races of humanoid creatures who left two "encyclopedias" containing the entire body of their knowledge; one is on Earth's moon, and the other is on Mars. The narrative weaves back and forth through time and several casts of characters to outline the history of these aliens. The Tiberians, seeking escape from frequent collisions between their home planet and a cloud of giant meteors, look Earthward (except that they call it Setepos; we're all Seteposians) and launch a kind of ark with which they land a colony at some time in the early Stone Age. Its story is told in the *Account of Zahmekoses*, a Tiberian's memoir translated by one of the book's principal characters. The colony's ultimate fate is not what the reader may expect. Then there is the *Account of Diehrenn*, a narrative written by a young female Tiberian who grew up as an Earth colonist.

Readers who like sci-fi made up of equal parts science and fantasy may enjoy the more exotic visions of the Tiberian

aliens and their technologies, especially the starships and the physics of their propulsion systems. Even here, you'll find that Tiberians too must honor the light-speed limit, and their ships are designed for voyages of ultra-long endurance.

But for those who just want to peek at where the two authors see Earth's space program evolving over about a hundred years' time, the portions of the novel interspersed between the Tiberian accounts will deliver the goods.

—George C. Larson

Kid Vid

Let's Go Fly a Helicopter. *Blue Beetle Productions, 1995. 27 minutes, $14.95 (VHS).*

Kids who already have their hearts set on a career with the local fire department will find this video an appealing twist on the shiny red fire engine theme that probably inspired the notion. For everyone else, *Let's Go Fly a Helicopter* might manage to spark some airborne ambitions.

Beginning with a brief look at the clumsy, skeletal predecessors to the modern helicopter, the video moves from a simplified explanation of aerodynamics into a modern factory, where workers are assembling the huge CH-53E Super Stallion. The video then joins the crews of helicopters working in a number of different fields, including an airborne sheriff's unit, a search-and-rescue team, and a logging operation in Oregon.

There are a few drawbacks: *Let's Go Fly a Helicopter* has a mildly annoying soundtrack, and it dwells too long on old footage of helicopter pioneer Igor Sikorsky, who speaks with such a thick Russian accent that his place in the video is more likely to baffle children than teach them anything. Those minor drawbacks, though, are offset by some cool visuals that are obviously designed to leave kids begging for Super Stallion plastic models and posters of the "Sky Crane," a flying oddity that looks remarkably like a giant orange dragonfly.

—Becki Bell is a journalism student at San Jose State University and a summer intern at Air & Space/Space/Smithsonian.

CREDITS

Queasy Rider. William P. Kelly Jr. was a U.S. Navy aviator from 1951 to 1970. He now works for the Federal Aviation Administration.

The Helicops. Writer Carl Hoffman has flown in all sorts of aircraft, but he never felt queasy in one until he experienced tight orbits over crime scenes with the Los Angeles police helicopter division.

Photographer Chad Slattery covers the world of aerospace from his home in Los Angeles. He last photographed "Out From the Shadow" for our 10th Anniversary issue (Apr./May 1996).

Splendor in Space. Frequent contributor Tony Reichhardt lives in Fredericksburg, Virginia.

Gerrit L. Verschuur is a professional radio astronomer and freelance writer living in Lakeland, Tennessee.

Forty Years of Falcos. Contributing editor Stephan Wilkinson claims to be getting too old to actually fly his Falco, but he gets endless pleasure out of polishing it.

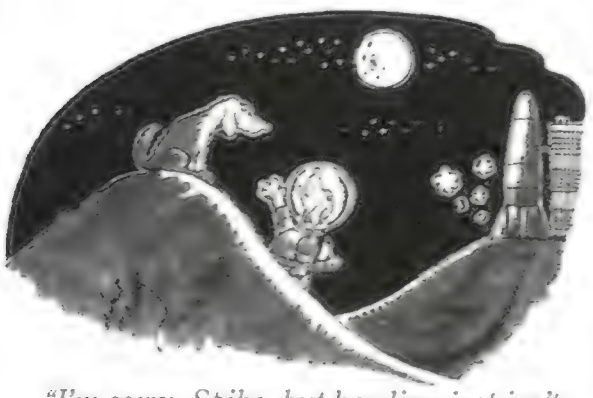
Richard Thompson draws for *National Geographic*, *The New Yorker*, and other unwitting publications. Since breaking his toe a few years ago, he has been forced to draw with his hands.

The New Millennium. William E. Burrows is an aerospace historian and the director of New York University's science and environmental reporting program.

Paul DiMare has been a professional illustrator for 19 years. He is a frequent contributor to *Air & Space/Smithsonian*.

The Climb to the Top. An aerobatic pilot himself, Larry Lowe previously wrote about the World Aerobatic Championships in "Ballet Among the Clouds" (Aug./Sept. 1994).

Dallas photographer Bill Crump has been fascinated by airplanes since boyhood. He has spent nearly 30 years shooting assignments for a variety of corporate clients and aviation institutions.



"I'm sorry, Spike, but howling just isn't enough anymore."

CREDITS

such as Bell Helicopter and the Confederate Air Force.

Let's Make a Deal. Bill Thomas, a former reporter for the *Baltimore Sun*, is the author of several books. The latest is *Capital Confidential*, published this year by Pocket Books.

Computer artist David Peters has a studio directly under the left turn pattern out of Santa Monica Airport/Cloverfield. Flybys welcome!

Who Made the Mustang? Peter Garrison's last feature for *Air & Space/Smithsonian* was "Lords of Landing" (April/May 1995).

Getting It Wright. Phil Scott wrote extensively on the Wright brothers in his book *The Shoulders of Giants* (Addison-Wesley, 1995).

CALENDAR

August 1-7
44th Annual Experimental Aircraft Association Fly-In. Wittman Regional Airport, Oshkosh, WI, (414) 426-4800.

August 2-4
Magic of Alexandria Balloon Festival. Alexandria Field Airport, Pittstown, NJ, (908) 735-0870.

August 15-18
9th World Helicopter Championships. McNary Field, Salem, OR, (703) 255-3272.

August 16-18
7th Annual Warbird Round-Up. Santa Maria, CA, (805) 922-8758.

August 17
AIRFEST '96. Craig Airport, Jacksonville, FL, (904) 630-3080.

August 17 & 18
"Wings of Eagles" Airshow. Batavia Airport, NY, (716) 345-0424.

Confederate Air Force Gathering of Memories Airshow. San Marcos, TX, (512) 396-1943

August 18
AIRFEST '96. Herlong Airport, Jacksonville, FL, (904) 630-3080.

11th Annual Vintage Aircraft Display. Capitol Airport, Brookfield, WI, (414) 781-9550.

August 23-25
1996 Ballunar Liftoff Festival. Rocket Park, Houston, TX, (713) 488-7676.

August 24 & 25
Wings of Freedom Airshow. Frederick, MD, (301) 631-5357.

August 27-September 1
325th Fighter Group Reunion. Holiday Inn, Homewood Suites, Fairborne, OH, (616) 731-2421.

August 30 & 31
4th Annual Antique Fly-In and Airshow. Hayward, CA, (510) 455-2300.

August 31-September 2
Cleveland National Air Show. Burke Lakefront Airport, OH, (216) 781-0747.

September 4-7
486th Bomb Group Reunion. Hospitality House, Williamsburg, VA, (314) 829-1482.

September 7 & 8
The Dallas Airshow. Dallas Love Field, TX, (214) 350-1651.

MERFI-EAA Regional Fly-In. Municipal Airport, Marion, OH, (513) 849-9455.

September 10-14
487th Bomb Group Reunion. Springfield, MO, (402) 336-3124.

September 19-22
446th Bomb Group Reunion. The Pines Resort Hotel, South Fallsburg, NY, (908) 388-2843.

September 20
"One Giant Leap" benefit for Airventure. Museum of Flying, Santa Monica Airport, CA, (310) 392-8822.

September 21 & 22
Wings Over Houston Airshow Festival. Ellington Field, TX, (713) 531-9461.

September 28 & 29
AIRSHO 96. Midland International Airport, TX, (915) 563-1000.

"The Satellite Sky" Update/55

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

- **Priroda** 4-23-96 TT
- **PAM-STU** 5-22-96 Shuttle
- **MSTI-3** 5-16-96 L-1011

300 to 630 MILES

- **Cosmos 2332** 4-24-96 PL
- **MSX** 4-24-96 VAFB
- **SAX** 4-30-96 CAC

630 to 1,250 MILES

- **White Cloud (3)** 5-12-96 VAFB

21,750 to 22,370 MILES

- **Astra 1F** 4-8-96 TT
- **Gorizont 32** 5-25-96 TT
- **Inmarsat 3** 4-3-96 CAC
- **Galaxy 9** 5-24-96 CAC
- **M Sat-1** 4-20-96 KOU
- **Palapa C-2** 5-16-96 KOU
- **Amos 1** 5-16-96 KOU

Launched but not in orbit

90 to 300 MILES

STS-77 U.S. research	5-19-96	down 5-29-96
Spartan 207 U.S. research	5-20-96	down 5-20-96
IAE Antenna U.S. research	5-20-96	down 5-20-96

DATA: SAUNDERS KRAMER

FORECAST

In the Wings...

The Tail Sitters. With a helicopter's take-off-from-anywhere versatility and a bomber's muscle, the Lockheed XFV-1 or the Convair XFY-1 Pogo would have provided the ultimate protection for an aircraft carrier. The drawback: There was only one guy who could fly it.

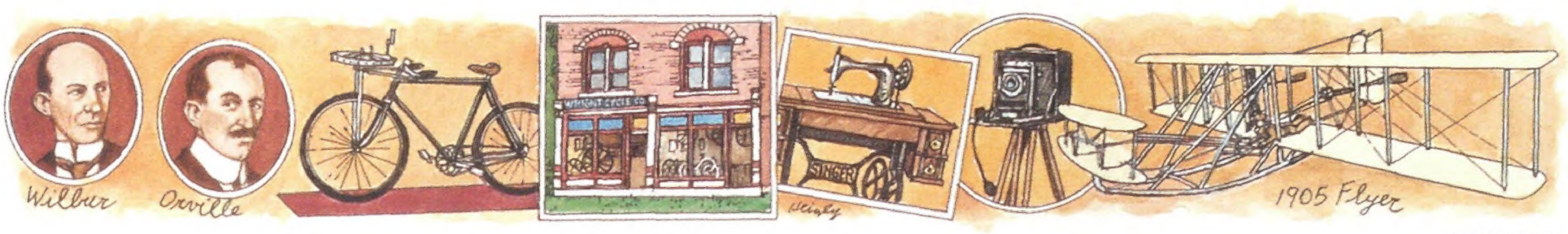
NASA's Next Rocket. One of three aerospace firms is about to be selected to design the X-33 reusable launch vehicle. The three proposals differ radically. How will NASA choose the winner?

Countering the Counterfeiters. The airline industry, the FAA, even the U.S. Congress are all studying the problem of keeping substandard parts off airliners. Part of the challenge lies in catching the incompetent as well as the criminal.

Reading the Air. Aerodynamicists use a number of methods to see how air flows around wings, fuselages, and intakes. We'll show you supercomputer modeling, Schlieren photography, vortex studies, and the smoke and dyes swirling in wind and helium tunnels to celebrate the opening of the National Air and Space Museum's new gallery, "How Things Fly."

How Theory Hid the Planets. The technologies were there. The astronomers were searching carefully. Why didn't they know where to look for other solar systems?

Home Is Where the ICBM Was. When your address is Atlas Missile Base Number Six, Topeka, you don't get much light, but you have plenty of closet space.



JOHN HEINLY

Getting It Wright

The Wright brothers' 1903 Flyer was, without question, their most famous creation, but it really wasn't much of an airplane. On the fateful December day when the inventors used it to make the world's first powered flights, the longest they could keep it flying was 59 seconds. The machine they built the following year didn't fly so well either, but their third airplane, the 1905 Flyer, stayed aloft for 39 minutes and 24 miles. This was the airplane in which the Wrights learned how to fly. With modifications, it carried the first passenger. It was, in short, the world's first practical airplane. Today, it is the centerpiece of a small, bucolic museum complex, Carillon Historical Park in Dayton, Ohio.

The 20-building park was developed just after World War II by a local industrialist, Colonel Edward Deeds, to commemorate the region's contributions to transportation. When Deeds approached fellow Daytonian Orville Wright, then in his 70s, and asked for a Flyer to display in the complex, Wright first suggested that Deeds obtain a replica of the famous 1903 machine. Then he got a better idea.

Back in 1912 he and Wilbur had donated the 1905 Flyer to the Berkshire Museum in Massachusetts. But the museum was unable to make the needed restorations and ended up stashing the craft in the basement. After Deeds approached him, Orville contacted the museum, and the staff agreed to return the Flyer to Dayton. With help from Harvey Geyer, a mechanic from the early days, Orville plunged into a restoration. By the time the inventor died in 1948 at the age of 76, it was nearly complete.

Geyer took over, and by 1950 the machine was assembled in its new home at Carillon Park: Wright Hall, a small red-brick Federal-style building. In keeping with Orville's wishes, the museum has displayed the meticulously restored Flyer in a sunken space to enable visitors to get a better view of it.

At first glance, the 1905 machine closely resembles its elder, more famous sibling at the National Air and Space Museum. Both have long rectangular biplane wings covered with yellowing "Pride of the West" muslin, an elevator in front, a rudder in back, twin pusher propellers, and a place on the lower wing for the pilot to lie prone. But the 1905 Flyer shows signs of the Wrights' evolution: The aircraft has been elongated to provide more stability, its engine is more powerful, and the overall structure is both sturdier and more gracefully curved. In addition, on the first Flyer the Wrights left all the exposed wood unpainted, while on the 1905 model, everything except the wings received a coat of silver paint. Fearful of spies, the brothers knew that the silver would wash out of any photographs, thus preserving the machine's secrets.

Carillon Historical Park, 2001 S. Patterson Blvd., Dayton, OH 45409. Phone (513) 293-2841. Open May 1–Oct. 31; Tues.–Sat., 10 a.m.–6 p.m.; Sun., 1–6 p.m. (closes at 5 p.m. in Sept. and Oct.). Admission: adults, $2; kids 6–17, $1; kids under 6 and members, free.

Carillon Park's executive director, Mary Mathews, says the best estimates are that the airplane is 60 percent original. "Original" depends on your perspective, though, for within the 1905 machine exist the only known remnants of the 1904 Flyer: the engine and perhaps a few pieces, such as the hip cradle and some uprights. "The brothers were prudent in using everything they had," says Mathews.

Though the airplane dominates the spare Wright Hall, it is surrounded by a few major artifacts donated by the Wright family. Next to the Flyer sits a huge toolbox, which accompanied the brothers' flight exhibition team when it toured the country in 1910 and 1911, giving hundreds of thousands of Americans their first glimpse of a heavier-than-air craft. On one side of the hall's entryway is an original Wright bicycle (one of only five known to exist). Fastened to the handle bars is a horizontal wheel with two test surfaces mounted on the rim; the Wrights designed the apparatus to measure how lift and air pressure would affect the test surfaces, as shown by the wheel's rotation.

On the other side of the entrance is a reproduction of the Wrights' first true wind tunnel—essentially a six-foot-long wooden box with a viewing window on top and a fan at one end. One family member donated the Singer sewing machine that the brothers used to stitch the muslin for the wings of their early aircraft, while another donated the Korona V camera that Kitty Hawk lifeguard John Daniels used to take the famous photograph of the first flight.

Next door to Wright Hall stands a replica of the Wright Cycle Company building, where the brothers built bicycles and, later, aircraft. Inside, visitors can see such machines as a 19th century drill press and lathe, as well as turn-of-the-century bicycles. (The original Wright Cycle Company building still exists, only no longer in Dayton: Henry Ford bought it in 1936 along with the house where the brothers grew up and moved every brick and plank to his own homage to American industry, Greenfield Village in Dearborn, Michigan.)

Rounding out the Wright collection are a few artifacts from the brothers' first career: printing. There's a woodcut Wilbur made of a cat's face, as well as one from a catalog they printed to advertise their bicycles. The museum also displays copies of newspapers the Wrights produced in the early 1890s, *The West Side News* and *The Evening Item*, in which Wilbur took on everything from labor conflicts to Dayton's sewer problems.

"All of these artifacts fill me with awe," says Mary Mathews. "The Wrights were two creative scientists and engineers who never even bothered to pick up their high school diplomas. They were also two down-to-earth people who made a lasting contribution to the whole world."

—Phil Scott

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